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Analysis of Gasoline Marketing Regulatory Strategies

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The gasoline marketing industry (bulk terminals, bulk plants, service station storage tanks, and service station vehicle refueling operations) emit to the atmosphere several organic compounds of concern. These include: volatile organic compounds (VOC), which contribute to ozone formation; benzene, which has been listed as a hazardous air pollutant based on human evidence of carcinogencity; and gasoline vapors, for which there is animal evidence of carcinogencity. This draft Regulatory Impact Analysis document is the first volume of a two-volume set that was prepared by EPA to fulfill the objectives of Title 3 - Executive Order 12291 (46 FR 13193, February 19, 1981) as they apply to future rulemaking on onboard control technology for controlling vehicle refueling air emissions. Volume 1 desribes changes to an environmental and economic analysis published by EPA in 1984 (EPA-450/3-84-012a and b). Volume II summarizes the results of more extensive supporting analyses of onboard costs and benefits that were prepared in the course of developing the onboard rulemaking (EPA-450/3-87-001b).

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Volume I

Analysis of Gasoline Marketing Regulatory Strategies

OFFICE OF AIR QUALITY PLANNING AND STANDARDS
AND
OFFICE OF MOBILE SOURCES

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Radiation
Washington, DC 20460

July 1987

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1.0 INTRODUCTION

This draft Regulatory Impact Analysis document is the first volume of a two-volume set that was prepared by the Environmental Protection Agency (EPA) to fulfill the objectives of Title 3 - Executive Order 12291 (46 FR 13193, February 19, 1981) as they apply to future rulemaking on onboard control technology for controlling vehicle refueling air emissions. Volume I describes changes to an environmental and economic analysis published by EPA in 1984 (I-A-55) and presents the results of the reanalysis. Volume II summarizes the results of more extensive supporting analyses of onboard costs and benefits that were prepared in the course of developing the onboard rulemaking.[1]

On August 8, 1984, EPA published in the Federal Register (49 FR 31706) notice of the availability of an analysis of regulatory strategies being considered for controlling air pollutant emissions from the gasoline marketing industry. Public comments were solicited and more than 180 individual comment letters were received. This document describes changes to the EPA 1984 analysis that were made as a result of these comments. Agency responses to public comments are provided in a separate document.[2] This Volume I document consists of three chapters plus appendices. This chapter introduces the purpose and contents of Volumes I and II. Chapter 2 and supporting appendices describe the changes made to the EPA 1984 analysis. Chapter 3 contains a summary of the impacts of these changes on key areas of the analysis.

Volume II provides a summary of the costs and benefits of the onboard rulemaking, including socio-economic impacts such as the effects on sales and employment in affected segments of the economy and impact on the balance of trade. Chapters 1, 2, and 3 of the Volume II document contain an introduction to and summary of the economic impacts and air quality benefits, respectively, of the onboard rulemaking.

All references used in this document are contained in EPA's Gasoline Marketing Docket (No. A-84-07). Each document in this docket is assigned a docket item number. These same docket item numbers are used as reference numbers in this document. The docket is available for public inspection and coping at EPA's Control Docket Section, West Tower Lobby, Gallery 1, Waterside Mall, 401 M Street, S.W., Washington, D.C. 20460 (phone number 202-382-7549). A reasonable fee may be charged for copying.

REFERENCES FOR CHAPTER 1

I-A-55. Evaluation of Air Pollution Regulatory Strategies for Gasoline Marketing Industry. U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards, and Office of Mobile Sources. EPA-450/3-84-012a (Executive Summary - EPA-450/3-84-012b). July 1984. [NTIS #PB 84 231075 and PB 84 231083, respectively].

1*. Draft Regulatory Impact Analysis, Proposed Refueling Emission Regulations for Gasoline-Fueled Vehicles -- Volume II - Additional Analysis of Onboard Controls. U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Mobile Sources. EPA-450/3-87-001b. July 1987.

2*. Evaluation of Air Pollution Regulatory Strategies for Gasoline Marketing Industry -- Response to Public Comments. U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards, and Office of Mobile Sources. EPA-450/3-84-012c. July 1987.

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2

2.0 CHANGES TO THE ANALYSIS

Many of the basic assumptions utilized in the EPA 1984 analysis were modified to respond to public comments and to update the analysis. These basic assumptions included typical Reid vapor pressure (RVP) and temperature of gasoline used in calculating emission estimates; projections of gasoline consumption and service station populations; and in-use control efficiencies and costs of Stage II and onboard control systems. In addition, the elements of the regulatory strategies considered in that analysis were updated to incorporate the concerns of commenters. Significant changes were made to the onboard control analysis, the consideration of excess evaporative emission controls and Stage II exemption levels, the identification of example nonattainment area groupings for evaluating Stage II impacts under various scenarios, and the projected startup and phase-in schedules that would apply to the regulatory strategies.

The purpose of this chapter is to summarize these changes and to present the results of the new regulatory analysis. As an aid in comparing with the analysis published by EPA in July 1984 (I-A-55), this summary will follow the same general order as used in that document. To obtain a more complete understanding of the methodology used to calculate the impacts in this report, the 1984 analysis should be consulted.

2.1 EMISSION SOURCES AND ESTIMATES

2.1.1 Emission Factor Parameters

The emission factors used in the July 1984 analysis were based on emission factors and equations from EPA's Compilation of Air Pollutant Emission Factors (Publication AP-42) (I-A-3). The emission factors obtained from that document generally were based on a Reid vapor pressure of 10 psi and a fuel temperature of 60°F. However, current data available concerning in-use fuels indicate that the RVP of these fuels has been increasing with time and is approaching the ASTM recommended limit (11.5 psi in the summer in Class C areas). In addition, winter RVP's exceed 11.5 psi and approach 14 psi in some areas of the country (I-F-16, -20, -28, -31, -34, -35, -45, -50, -52, -76, -88). Assuming that future summer gasolines reached the 11.5 psi value and remained constant, and winter gasolines remained constant at their current levels, the weighted average nationwide RVP would be 12.6 psi. This value was derived by EPA based upon nationwide data on RVP. The RVP was weighted by the county gasoline consumption to obtain a nationwide average. This model also generated data on product underground temperature, dispensed fuel temperature, and the difference between dispensed fuel temperature and vehicle tank temperature.

The EPA analysis evaluated not only nationwide regulatory strategies, but also strategies for nonattainment areas. The Agency analyzed three nonattainment area strategies; one for 61 areas, one for 27 areas, and one for 11 areas (discussion of the selection of these areas can be found in Section 2.3.3.4). Since these nonattainment area groupings consisted of different county mixes, and EPA had a model with RVP and temperature data on a county-by-county basis, different RVP and temperature data were used for each nonattainment area strategy. Table 2-1 indicates the RVP and temperature data corresponding to each regulatory area.

2.1.2 Baseline Emission Factors

2.1.2.1 Stage I. The RVP and temperature data applied in the model discussed above were used in the API equations found in AP-42 to generate new emission factors for tank truck loading at bulk terminals and bulk plants, and for the filling of service station underground storage tanks. The data were also used in the latest API fixed-roof and floating-roof tank equations (I-A-43, -45) for calculating emissions from storage tanks at terminals and bulk plants. Compared to the results obtained in the 1984 EPA analysis, there was a significant drop in the fixed-roof tank breathing loss factor for bulk plants. This was due mainly to a change in the API equations that estimate fixed-roof tank breathing loss emissions.

The emission factors for underground tank "breathing" and spillage during vehicle refueling were not changed. An investigation of the original source of the underground tank breathing factor (I-F-118) indicated that these emissions were really "emptying" losses. No information was provided in this reference on the RVP of the gasoline upon which the emptying loss emission factor was based; consequently, there were insufficient data to determine the effect that changes in RVP

Table 2-1. RVP AND TEMPERATURE DATA ASSOCIATED WITH EACH REGULATORY AREA EXAMINED

Regulatory Area	RVP[a]	Fuel Temperature, °F[a] Dispensed Fuel	Underground Tank	ΔT[b]	Aboveground Tank[c]
Nationwide	12.6	68.9	60	4.4	66
Nonattainment[d]					
- 61 areas[e]	12.6	68.9	60	4.4	66
- 27 areas	12.9	65.4	59.4	5.3	66
- 11 areas	12.6	66.0	63.1	5.1	66

[a] Weighted annual average.

[b] ΔT is the difference between the dispensed fuel temperature and the vehicle tank temperature.

[c] Assumed constant for all areas because data were not available on area-specific aboveground tank temperatures. The temperature used (66°F) is the same as that used in the July 1984 analysis.

[d] Nonattainment area selections are discussed in Section 2.3.3.

[e] Since 61 areas is a large number of nonattainment areas and they are located in most areas of the country, values are assumed to be equal to nationwide values.

would have on the emission estimate. The vehicle refueling spillage factor was not changed because spillage emissions are considered to result from the total evaporation of spilled gasoline. Changing the RVP did not significantly change the density of the liquid gasoline; therefore, the spillage emission factor was unchanged.

2.1.2.2 Vehicle Refueling. The vehicle refueling emission factor was generated by using the RVP and temperature information from the EPA model discussed earlier and an empirical equation generated by EPA. The empirical formula, based upon additional vehicle refueling tests conducted by EPA (I-A-69), is as follows:

$$E_R = 264.2\ [(-5.909) - 0.0949\ (\Delta T) + 0.0884\ (T_D) + 0.485\ (RVP)]$$

where:

E_R = Refueling emissions, mg/liter

ΔT = Difference between temperature of fuel in vehicle tank and temperature of dispensed fuel, °F

T_D = Temperature of dispensed fuel, °F

RVP = Reid vapor pressure, psia

Table 2-2 contains a summary of the emission factors used in the 1984 EPA analysis and the corresponding revised emission factors used in the new analysis. Since different RVP and temperature data apply to each regulatory area examined, different emission factors were derived for each area grouping.

Use of the revised emission factors resulted in changes throughout the new analysis. Baseline emissions and emission reductions attributed to the regulatory strategies increased with the increased emission factors. Costs for many of the strategies decreased because increased emission factors resulted in higher recovery credits. Both decreased costs and increased emission reductions work toward lowering the cost effectiveness values for the control scenarios (dollars per megagram of emissions reduced). Increased emission factors also resulted in higher estimated rates of cancer incidence and increased lifetime risks due to high exposure associated with gasoline marketing operations (except for

Table 2-2. SUMMARY OF EMISSION FACTORS USED IN THE GASOLINE MARKETING ANALYSIS

	Emission Factors			
		New Analysis[b]		
Source	July 1984 Analysis[a]	Nationwide, 61 NA[c] Areas	27 NA[c] Areas	11 NA[c] Areas
BULK TERMINALS				
o Truck Loading				
- Splash Fill (mg/liter)	1,440	1,936	1,912	1,936
- Submerged Fill (mg/liter)	600	801	791	801
- Controlled Loading				
o NSPS (mg/liter)	35	35	35	35
o SIP (mg/liter)	80	80	80	80
o 90% (mg/liter)	96	133.5	131.9	133.5
- Truck Leakage				
o 10% (mg/liter)	96	133.5	131.9	133.5
o 30% (mg/liter)	288	400.5	395.6	400.5
o Storage Tanks				
- Fixed Roof				
o Breathing (Mg/yr/tank)	8.8	12.7	13.3	12.9
o Working (Mg/yr/tank)	34.2	46.3	47.7	46.9
- Floating Roof (Internal)				
o Rim Seal Loss (Mg/yr/tank)	0.49	0.74	0.78	0.75
o Fitting Loss (Mg/yr/tank)	1.39	1.60	1.68	1.63
o Deck Seam Loss (Mg/yr/tank)	0.55	0.84	0.88	0.85
o Working Loss (Mg/yr)	7.33×10^{-8} Q[d]	f	f	f
- Floating Roof (External)				
o Primary Seal (Mg/yr/tank)	9.63	14.57	15.29	14.86
o Secondary Seal (Mg/yr/tank)	3.22	4.87	5.11	4.96
o Working Loss (Mg/yr)	4.61×10^{-8} Q[d]	f	f	f
BULK PLANTS				
o Truck Loading				
- Splash Fill (mg/liter)	1,440	1,936	1,970	1,936
- Submerged Fill (mg/liter)	600	801	815	801
- Balance Service	960	1,335	1,359	1,335
- Controlled Loading (Balance Service)	96	133.5	135.9	133.5
- Truck Leakage				
o 10% (mg/liter)	96	133.5	135.9	133.5
o 30% (mg/liter)	288	400.5	407.7	400.5

Footnotes are shown on next page.

Table 2-2. SUMMARY OF EMISSION FACTORS USED IN THE GASOLINE MARKETING ANALYSIS (concluded)

	Emission Factors			
		New Analysis[b]		
Source	July 1984 Analysis[a]	Nationwide, 61 NA[c] Areas	27 NA[c] Areas	11 NA[c] Areas
BULK PLANTS (concluded)				
o Storage Tanks				
- Uncontrolled				
o Breathing (mg/liter)	600	228	235	228
o Filling (mg/liter)	1,150	1,174	1,194	1,174
o Emptying (mg/liter)	460	469	478	469
- Controlled				
o Breathing (mg/liter)	600	228	235	228
o Filling (mg/liter)	57.5	59	60	59
o Emptying (mg/liter)	46	47	48	47
SERVICE STATIONS				
o Underground Tanks				
- Submerged Fill (mg/liter)	880	1,075	1,084	1,133
- Splash Fill (mg/liter)	1,380	1,691	1,705	1,782
- Emptying Loss (mg/liter)	60	120	120	120
- Breathing Loss (mg/liter)	60	0	0	0
- Controlled Fill (mg/liter)	40	49	49	52
- Other Controlled Fill				
o Florida (mg/liter)	80	80	80	80
o Texas (mg/liter)	144	144	144	144
o Louisiana (mg/liter)	144	144	144	144
o New Mexico (mg/liter)	138	138	138	138
o Automobile Refueling				
- Displacement (mg/liter)	1,080	1,552	1,486	1,467
- Spillage (mg/liter)	84	84	84	84
- Controlled Displacement				
o 97% efficient (mg/liter)	32	47	45	44
o 93% efficient (mg/liter)	76	109	104	103
o 86% efficient (mg/liter)	151	217	208	205
o 62% efficient (mg/liter)	410	590	565	557
EXCESS EVAPORATIVE				
o Light duty vehicles (gm/mile)	0	0.175	0.175	0.175
o Light duty trucks[e] (gm/mile)	0	0.255	0.255	0.255
o Heavy duty gasoline vehicles[e] (gm/mile)	0	0.418	0.418	0.418

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[a] Emission factors used in July 1984 analysis.

[b] New emission factors for each selected regulatory area based on RVP and temperatures found in Table 3-1.

[c] NA = Nonattainment.

[d] Q = Throughput in barrels per year.

[e] Weighted average.

f = Unchanged from July 1984 Analysis.

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self-service and occupational exposures, which are based on monitoring data), and increased incidence reductions associated with the regulatory strategies. Again, increased risk reductions and decreased costs both lead to a reduction in the other measure of cost effectiveness (dollars per cancer incidence avoided) evaluated for the regulatory strategies.

2.1.2.3 Excess Evaporative. Emission factors were also derived to estimate emissions from existing vehicle carbon canisters installed to control evaporative emissions. Studies have shown that these canisters are undersized relative to the increased volatility of commercially available gasoline, resulting in evaporative emissions in excess of the applicable standards (I-B-24). The EPA estimated the amount of evaporative emissions currently being lost from existing canisters that was controllable by either enlarging the existing canister or reducing RVP. These "controllable" excess evaporative emissions are reflected in the emission factors in Table 2-2. Other evaporative emissions, such as those from hose leaks and other leaks, are not included in the "controllable" excess evaporative emission factors.

2.2 CONTROL TECHNOLOGY AND EFFECTIVENESS

The only changes to the control technology being evaluated in the new analysis concern the onboard technology. The rigid nozzle fillneck seal assumed in the July 1984 analysis was replaced by the "J-tube" liquid seal system, as discussed in Section 2.2.1. This new system concept resulted in a higher in-use efficiency being attributed to the onboard system (93 percent instead of 92 percent), as discussed in Section 2.2.2 and Appendix A.

No changes were considered in the Stage II control technology evaluated. The in-use efficiency attributed to minimal enforcement was increased from 56 percent to 62 percent. Again, see Section 2.2.2 and Appendix A for further discussion of in-use efficiencies.

2.2.1 Onboard Control Technology

There are differences between the onboard technology being evaluated in the new analysis and the technology evaluated in the July 1984 analysis. In the July 1984 analysis, the onboard control technology included a rigid nozzle/fillneck seal that would seal around the nozzle spout, preventing the vapors from escaping at the nozzle/fillneck interface and ensuring that the vapors were routed to the onboard carbon canister (see Figure 2-1). In the new analysis, the rigid fillneck

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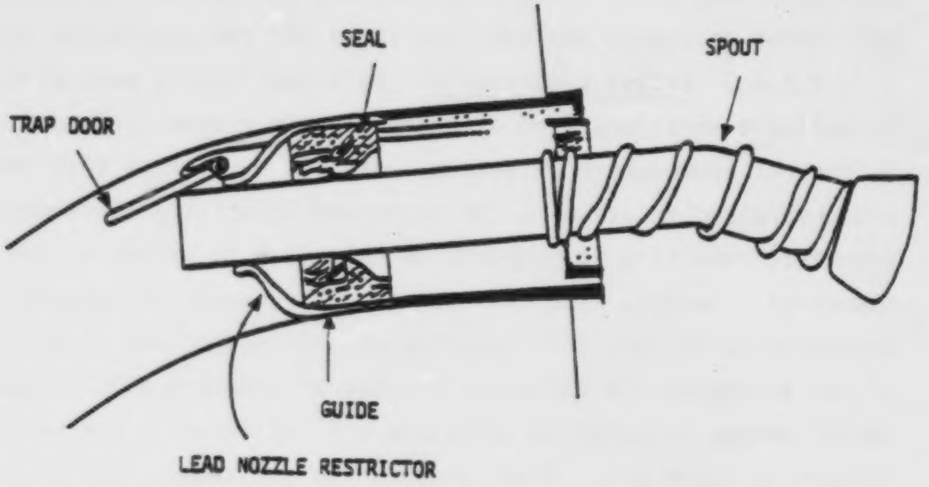
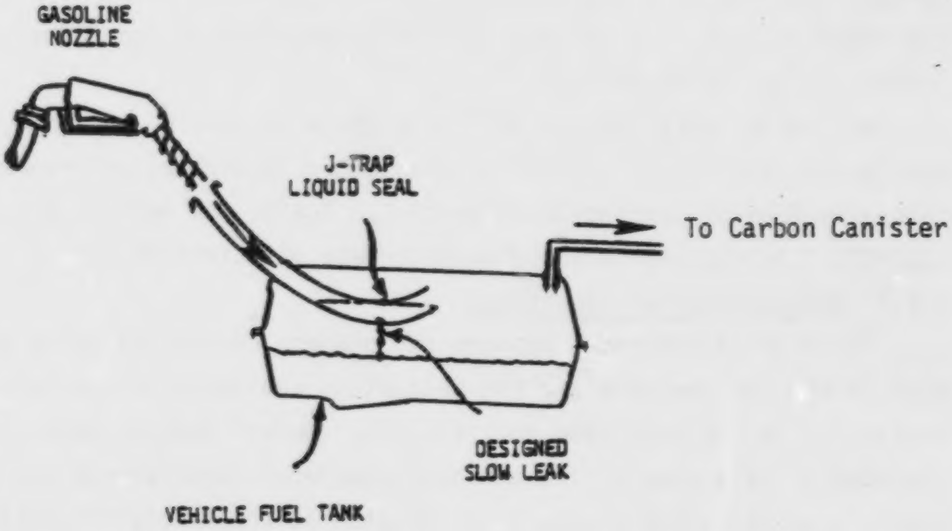

SEAL
SPOUT
TRAP DOOR
GUIDE
LEAD NOZZLE RESTRICTOR

Rigid Nozzle/Fillneck Seal


GASOLINE NOZZLE
J-TRAP LIQUID SEAL
To Carbon Canister
DESIGNED SLOW LEAK
VEHICLE FUEL TANK

J-Tube Liquid Seal

Figure 2-1. Onboard Fillneck Seal Mechanisms

seal is replaced by a "J-tube" fillpipe arrangement that creates a liquid seal in the fillneck during vehicle refueling. This liquid seal accomplishes the same objective as the rigid fillneck seal; however, the liquid seal is not subject to fuel switching-motivated tampering (removal of the unleaded gasoline restricter does not affect the efficiency of the liquid seal system). Since fuel switching-motivated tampering has no effect on the vapor sealing system, the J-tube yields a higher in-use control efficiency than does the rigid seal.

2.2.2 In-Use Efficiencies

In the July 1984 analysis, data on malfunctions, defects, and tampering were used to adjust the theoretical efficiency to obtain an estimate of the actual in-use efficiency. For the new analysis, additional information from new studies was obtained to allow the revision of some of the in-use efficiencies. Appendix A discusses the in-use efficiency methodologies in greater detail.

2.2.2.1 Onboard. For the onboard control system, the in-use efficiency for refueling emissions applied in the July 1984 document was 92 percent (theoretical efficiency = 98 percent). This in-use efficiency was based upon the latest canister and fillneck tampering rates available at the time the analysis was published. Since that time, new canister tampering data have been obtained (I-A-40). In addition, the technology being evaluated for onboard was modified, eliminating the rigid fillneck seal and replacing it with a liquid seal (J-tube). This change in design eliminated the impacts of fillneck tampering; therefore, the new in-use efficiency was based upon canister tampering only (which is much smaller than fillneck tampering). The new analysis assumes that non-tampered onboard systems would operate at theoretical efficiency (97 percent), and tampered systems would operate at 0 percent efficiency. Using the various tampering rates by vehicle class, the annualized in-use efficiency of onboard for refueling emissions was calculated as 93 percent of displacement losses during refueling operations.

2.2.2.2 Stage II. For Stage II control systems, a survey of all Stage II gasoline service station facilities was conducted in Washington, D.C., during the summer of 1984 (I-A-61). The survey was important because Washington, D.C. was the only place outside California that required Stage II. The history of enforcement indicated that California has an active, aggressive enforcement program and would represent the upper end of the Stage II efficiency range. Washington, D.C., at the time of the survey, did not have an active enforcement program and the experience there was considered representative of the lower end of the efficiency range. Since that time, the City has begun to implement a more vigorous Stage II enforcement and maintenance program.

In the Washington, D.C. survey, information was gathered on the frequency of such defects as torn or missing nozzle boots and faceplates, torn or missing vapor hoses, missing high-hang hose retractors, improper hose drainage, and nozzle operation problems. In addition, data were gathered on the number of nozzles where no vapor recovery equipment was installed. Non-installation was divided into two categories: (1) those stations that installed no vapor recovery equipment, and (2) those stations that had installed Stage II on a majority of the pumps but had one or more nozzles without vapor recovery installed. (See Appendix A for more details.) Approximately 4 percent of the stations did not install any vapor recovery equipment, based on the latest inspection report. For those stations that had installed Stage II, approximately 10 percent of the nozzles still had no vapor recovery.

These data were used to re-evaluate the Stage II in-use efficiency applicable to this area. In the 1984 EPA analysis, an overall in-use efficiency of 56 percent was calculated for minimal enforcement, based on the inspection data available at that time. The new analysis incorporates the latest inspection data, and an in-use efficiency of 62 percent for the minimal enforcement level was calculated.

The upper end of the Stage II efficiency range was based on Stage II systems in California. Insufficient data were available to justify an adjustment of the upper in-use value used in the 1984 EPA analysis; therefore, the upper end of the Stage II in-use efficiency range remained at 86 percent.

2.2.2.3 Excess Evaporative. Excess evaporative emissions consist of gasoline vapor currently being lost from under-sized evaporative carbon canisters on automobiles. The emission factors discussed in Section 2.1.2 represent the portion of these excess evaporative emissions that are "controllable" (i.e., do not include emissions from leaks but only those emissions that are lost due to insufficient carbon capacity). These "controllable" emissions can be eliminated primarily by increasing the size of the carbon canister. Therefore, the control efficiency assumed in the new analysis for the controllable excess evaporative emissions is 100 percent.

2.3 MODEL PLANTS AND REGULATORY STRATEGIES

The purpose of this section is to describe the changes made to the model plants and regulatory strategies used in the July 1984 analysis. One change in the new analysis that affects all regulatory strategies was a shift in the base year from 1982 to 1984. This shift was made to bring the analysis more up-to-date and to reflect the latest information on service station population and gasoline consumption.

2.3.1 Model Plants

No changes were made to the model plants that represent the bulk terminal, storage tank, and bulk plant industry sectors. In addition, no changes were made in the assumptions concerning the number of these types of facilities that would require controls under the regulatory strategies.

For service stations, more details concerning the physical layout of the model plants were added to the analysis. These details were required to allow a more accurate cost assessment of aboveground and underground Stage II equipment. (Appendix B discusses the physical layout of each service station model plant.) In addition, several commenters felt that the Model Plant 1 throughput (5,000 gallons/month) was too high to represent the private sector, which forms the majority of the facilities in Model Plant 1 (approximately 80 percent), and that 2,000 gallons/month would be more representative. The EPA reanalyzed the existing data and agreed that 2,000 gallons/month would better represent the throughput at a private facility, but would be too small, given the installed equipment (2 nozzles), for a public facility. Therefore, in the new analysis, Model Plant 1 was divided into a private facility (2,000 gallons/month) and a public facility (6,000 gallons/month). Both are considered Model Plant 1's because both facility types have similar physical equipment and layout.

The size distribution of the remainder of the service station model plants remained the same as in the July 1984 analysis. However, the parameters defining the model plants were expanded somewhat to accommodate the evolving trends in gasoline dispensing hardware. The Agency has concluded that a significant portion of existing and new service stations installing Stage II would be using multiproduct dispensers (i.e., equipment where each grade of gasoline is available separately on two sides of the dispenser). Therefore, in addition to the base case where single product dispensers were assumed, an additional configuration of two-product, 4-nozzle multiproduct dispensers has been added to the analysis. Table 2-3 indicates the number of nozzles assumed for both single and multiproduct dispenser cases. The consideration of additional Stage II hardware scenarios is fully discussed in Appendix I, and system costs are estimated in Appendix B.

Several commenters questioned the number of facilities assumed in the July 1984 analysis (210,900 public stations, 210,300 private stations for the 1982 base year). The EPA reviewed available data and revised the public station total to 190,000 to reflect the latest estimate for the new 1984 base year (I-F-124). No data were available to adjust the private facilities total to reflect 1984, so this value remained at 210,300.

In addition to changing the number of service stations to reflect the new base year, the new analysis also projects the number of stations in each year out to the year 2020. The following section and Appendix D discuss the projection methodology used in the analysis.

2.3.2 Gasoline, Facility, and Vehicle Projections

2.3.2.1 Gasoline Projections. In the July 1984 analysis, the gasoline consumption was projected from the present to the year 2000 using a graphical approach based on data available from EPA studies used in the 1982 gasoline lead phasedown program (47 FR 49329). The consumption was assumed to remain constant from the year 2000 to the year 2020 because of the lack of available data and because of the uncertainty of projecting gasoline consumption far into the future. In the new analysis, the gasoline consumption projections were based on EPA's MOBILE3 Fuel Consumption Model (I-A-99, I-B-37). This model uses inputs consistent with the widely accepted MOBILE3 Emission Factor

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Table 2-3. ESTIMATED 1984 SERVICE STATION SIZE DISTRIBUTION

Model Plant No.		1a	1b	2	3	4	5	Totals
Average Throughput 10^3 l/mo		7.6	23	76	132	246	700	-
(10^3 gal/mo)		(2)	(6)	(20)	(35)	(65)	(185)	
Number of Nozzles	Single dispensers	2	2	3	6	9	15	
	Multidispensers	4	4	4	8	12	20	
"Public" Service Stations								
- Independents		-	8,900	17,700	22,500	10,400	2,600	
- Nonindependents		-	40,500	39,300	27,900	16,200	4,000	
- Total		-	49,400	57,000	50,400	26,600	6,600	190,000
- Percent		-	26	30	26.5	14	3.5	100.0
"Private" Service Stations								
Population		189,200	-	8,600	7,400	4,200	800	210,300
Percent		90	-	4.1	3.5	2.0	0.5	100.0
Total Facilities								
Population		189,200	49,400	65,600	57,800	30,800	7,400	400,200
Percent		47	12	16	14	8	2	100.0
Throughput								
(% of total consumption)		5.1	4.0	17.8	27.4	27.1	18.5	100.0

Model, such as projections for vehicle fleet registrations, fleet fuel economy, vehicle miles traveled, fleet diesel penetration rates, and vehicle fuel switching and tampering rates for both on- and off-highway light-duty vehicles, light-duty trucks, and heavy-duty trucks. Table 2-4 illustrates the differences in the projected gasoline consumption figures used in the July 1984 analysis and the new analysis. Due to uncertainties associated with projecting several variables (e.g., miles per gallon) beyond the year 2000, these variables were held constant after that year. Thus, gasoline consumption is still projected to remain constant after the year 2000.

A revised gasoline consumption projection affects all portions of the gasoline marketing analysis because most of the cost, emission reduction, and incidence reduction projections are based directly or indirectly on the gasoline consumption projections.

2.3.2.2 Service Station Projections. In the July 1984 analysis, the service station population was held constant at the 1982 base year level because it was felt there were insufficient data available to prepare reasonable projections. Several commenters remarked that the number of service stations has decreased since 1982, and is expected to continue to decrease. In the reanalysis, a model was developed that would change the base year number of facilities with time to reflect changes in gasoline consumption and to reflect industry trends. This model was patterned after a procedure prepared by Sierra Research Corporation for the Ford Motor Company (I-F-100, I-H-114).

The facility projections used in the EPA model apply only to public service stations. The number of private stations (private company fleet operations, police, government, etc.) was considered to stay constant with time, since the market pressures associated with decreasing consumption and shifts to more efficient stations are not likely to apply to private facilities. In the model, however, the throughput projection for private facilities was decreased in proportion to the decrease in total gasoline consumption to reflect the impact of decreased overall consumption caused by increased fuel economy.

The total number of public stations was adjusted to reflect a new base year of 1984 rather than 1982. The number of public stations was then projected with time to reflect the decrease in consumption and the

Table 2-4. COMPARISON OF TOTAL GASOLINE CONSUMPTION PROJECTIONS

	Total Gasoline Consumption, 10^9 gal/yr[a]	
Year	July 1984 Analysis	New Analysis
1984	92.3	92
1985	89.2	90
1986	86.1	88.5
1987	83.8	87
1988	81.5	85.5
1989	79.2	84.5
1990	77.7	83
1991	76	82
1992	75	81
1993	74	80
1994	72	79
1995	71	78
1996	70	77
1997	69	76
1998	68	76
1999	67	75
2000-2020	66	75

[a] Total consumption including agricultural usage. Agricultural usage varies from year to year but averages about 1 percent of the total.

industry trend toward larger stations. The total number of stations was decreased in proportion to the decrease in gasoline consumption (based on the gasoline consumption projections discussed in the previous section). In addition, the model took into account a shift to more efficient facilities by the closing of some existing smaller public stations and the opening of new larger facilities. The model tracks, for each year, the total number of stations, the number of stations in each model plant size, and the type of station (public, private, independent, nonindependent). Appendix D discusses the methodology used for this model in greater detail.

Table 2-5 presents the results of the service station projection model. Shown are the total number of service stations in each year, the total number of public stations in each year, and the number of public stations for each year for each model plant size. As a check, the model compares the total consumption in each year (from the fuel consumption model) with the consumption obtained by multiplying the number of facilities in each model plant size by their respective model plant throughputs. In no case did the yearly consumptions differ by more than 3 percent.

The use of the facility projections model affected the service station costing because: (1) the number of facilities changed with time, (2) the closing of small facilities and opening of large facilities changed the facility size distribution with time (this also affected the evaluation of exempting certain size stations), and (3) the tracking of each type of facility in each year allowed for the inclusion of a cost differential between new and existing facilities.

2.3.3 Regulatory Strategies

Most of the regulatory strategies evaluated in the July 1984 analysis were retained in the new analysis. Several regulatory strategies that were considered in combination with Stage I nationwide controls were not included in the new analysis (Stage I plus Stage II nationwide, Stage I plus onboard, Stage II in nonattainment areas plus Stage I plus onboard, Stage I plus Stage II plus onboard - nationwide). These were dropped to simplify the analysis and because the Stage I - nationwide alternative, still carried in the analysis, can be directly added to most of the strategies to determine the impacts of combining this alternative with other strategies.

Table 2-5. RESULTS OF SERVICE STATION FACILITY PROJECTION MODEL

Year	Number of Facilities						
	Total of All Facilities[a]	Total of All Public Facilities	Public Facilities by Model Plant				
			MP1[b]	MP2	MP3	MP4	MP5
1984	400,250	190,000	49,400	57,000	50,350	26,600	6,650
1985	395,489	185,239	47,888	55,581	48,996	26,207	6,567
1986	391,129	180,879	46,502	54,282	47,754	25,849	6,492
1987	387,206	176,956	45,256	53,113	46,638	25,526	6,423
1988	383,723	173,473	44,150	52,075	45,646	25,239	6,363
1989	380,699	170,449	43,189	51,174	44,786	24,990	6,310
1990	377,998	167,748	42,332	50,370	44,017	24,767	6,262
1991	375,319	165,069	41,481	49,571	43,255	24,546	6,216
1992	372,622	162,372	40,624	48,768	42,487	24,324	6,169
1993	369,931	159,681	39,769	47,966	41,721	24,102	6,123
1994	367,335	157,085	38,944	47,192	40,982	23,889	6,078
1995	364,647	154,397	38,090	46,391	40,218	23,667	6,031
1996	362,362	152,112	37,365	45,711	39,567	23,478	5,991
1997	360,529	150,279	36,782	45,165	39,045	23,328	5,959
1998	359,028	148,778	36,305	44,717	38,619	23,204	5,933
1999	357,821	147,571	35,922	44,357	38,275	23,104	5,913
2000-20	356,938	146,688	35,641	44,095	38,024	23,031	5,897

[a] Estimate includes all public and private gasoline dispensing facilities, including estimates of new facilities. Does not include farms and other small operations for refueling agricultural-related equipment.

[b] MP1 = Model Plant 1. Model plants described in Table 2-3.

Several new regulatory strategies were added to the analysis. These strategies centered around the evaluation of excess evaporative emission controls (discussed later in this section). New strategies added to the analysis include: control of excess evaporative emissions (evap controls) by using enlarged carbon canisters, evaluation of the combination of evap controls with Stage II nationwide and Stage II in nonattainment areas, evaluation of onboard controls incorporating the benefits associated with evap controls, and the evaluation of Stage II controls in nonattainment areas plus onboard with evap controls.

The specific areas evaluated as nonattainment areas in the new analysis have also changed. These are discussed later in this section and are presented in Appendix G.

2.3.3.1 Strategy Implementation. Due to the time required to analyze the regulatory alternatives and to fully respond to public comments, the dates on which the strategies were presumed to take effect had to be revised. In the July 1984 analysis, it was assumed that Stage II installations under nonattainment area regulatory programs would begin in 1986, Stage II installations under nationwide regulatory programs would begin in 1987, and onboard installations would begin with the 1988 model year.

Under the new analysis, the same assumptions were used in determining the time necessary to implement the regulatory strategies. The July 1984 analysis assumed a regulatory decision in late 1984, whereas the new analysis assumes a decision in early 1987. Therefore, the dates associated with the beginning of equipment installation for the regulatory strategies in the new analysis were assumed as 1990 for nationwide Stage II strategies (which includes time to prepare required support documents and Federal regulations) and the 1990 model year (considered January 1990 to simplify the analysis) for onboard and excess evaporative strategies (which includes time to promulgate standards and allows 2 model years to get the system into production after the standard's promulgation). The onboard and excess evaporative emission strategies assume that the onboard controls would be installed on new vehicles and would phase in as the vehicle fleet turns over. Figure 2-2 illustrates the time units for the respective start dates and equipment phase-ins.

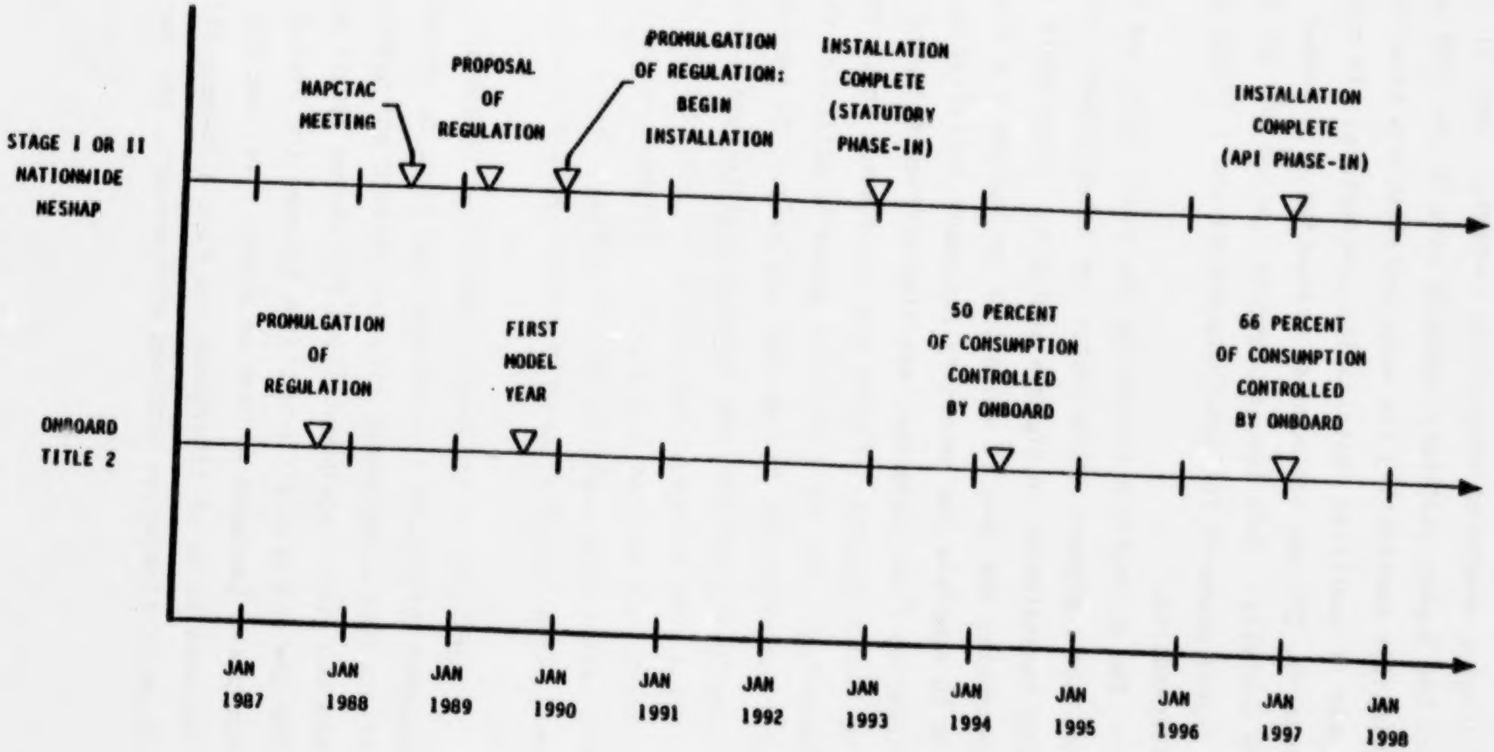

Figure 2-2. Comparison of Implementation Schedules For Nationwide Strategies

The phase-in schedule that EPA assumed for the nationwide Stage II strategies generated many public comments. Several commenters felt that the 3-year statutory phase-in used in the 1984 analysis was too optimistic considering the many installations required and the limited number of qualified installation contractors. To respond to industry's concerns, EPA has included an evaluation of a longer phase-in period in the analysis. This longer phase-in (called the API Phase-In) includes a 3-year phase-in for non-independents and a 7-year phase-in for independents.

The assumptions concerning the start dates and the schedule to complete equipment installation for nonattainment area strategies were also re-evaluated in the new analysis. Since there is some uncertainty concerning how long it would take to implement a Stage II regulation and to complete the necessary equipment installation, three phase-in scenarios (low, moderate, and high-difficulty) were examined to assess the likely impacts. Figure 2-3 illustrates these three implementation scenarios. The low-difficulty scenario maintains the 3-year equipment phase-in used in the 1984 analysis. The moderate-difficulty scenario assumes the same Federal Register announcement date, but projects a 6-month longer implementation period than the low-difficulty scenario, as well as a 3 1/2-year equipment phase-in. Finally, the high-difficulty scenario assumes a start date 1 year later than the moderate-difficulty scenario and projects a 5 1/2-year equipment phase-in.

For Stage II strategies combined with onboard, the 1984 analysis assumed that Stage II equipment would not be replaced after completion of one useful equipment life for balance and hybrid systems (15 years) and two useful equipment lives for vacuum assist systems (16 years). The new analysis differentiates between the useful life of aboveground equipment (assumed to have an 8-year life) and the underground piping (assumed to be of fiberglass and have a 35-year life). When evaluating Stage II strategies combined with onboard, the new analysis assumes

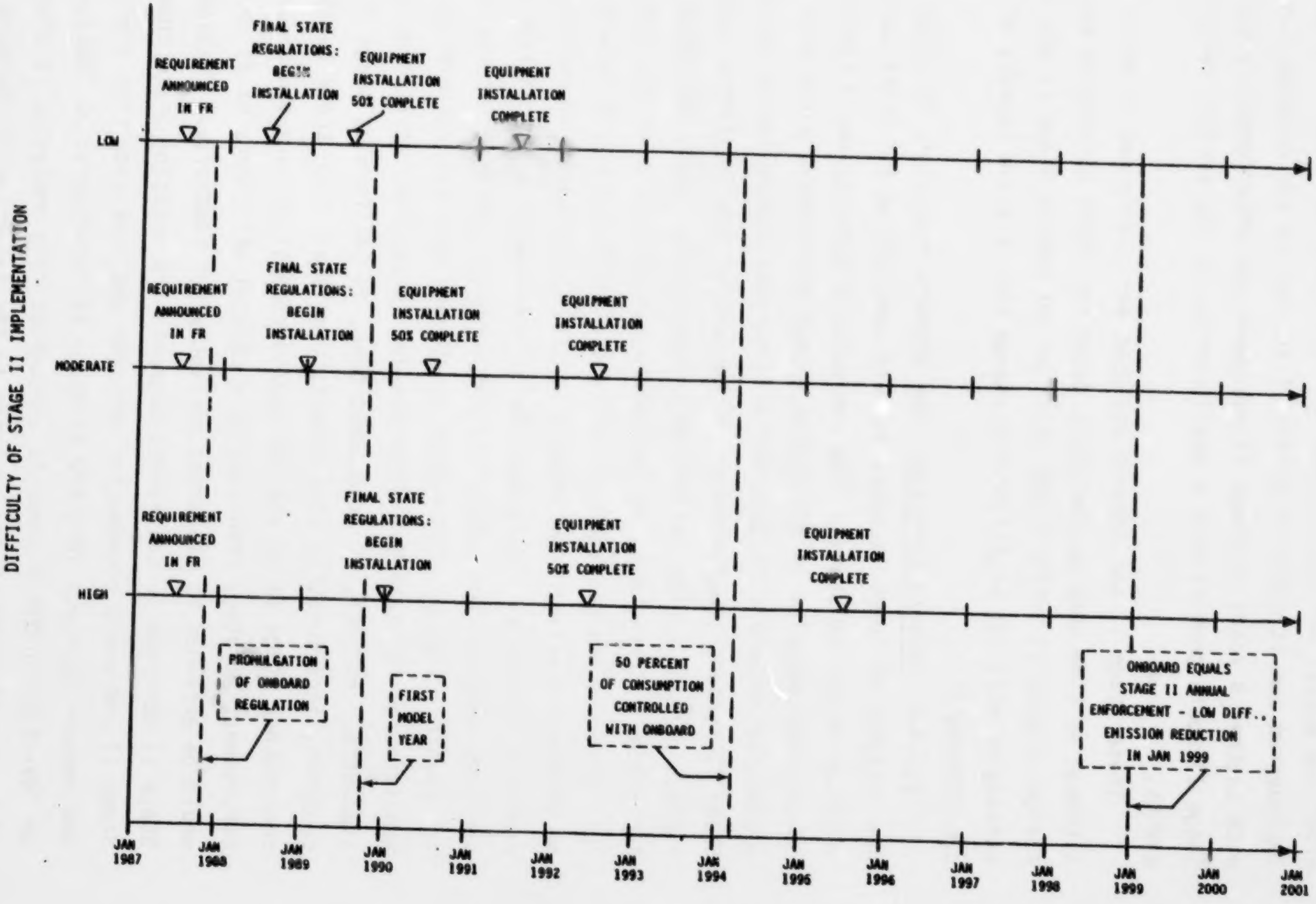

Figure 2-3. Comparison of Implementation Schedules for Stage II in Nonattainment Areas and Onboard Nationwide

that the aboveground equipment is not replaced after one 8-year lifetime. After the 8-year period, onboard controls would be close to 70 percent implemented and it would be difficult to require the expenses associated with another 8 years of Stage II equipment and enforcement, since Stage II would control only a small portion of the vehicle refueling events.

These Stage II and onboard analyses were performed in early 1987 and, although as time goes on the start dates for these strategies may change, a general shift in the start of nationwide Stage II and onboard strategies will not significantly change the relative impacts of the strategies.

2.3.3.2 Onboard Coverage. The onboard regulatory strategy in the new analysis no longer assumes onboard controls on all light-duty vehicles in all 50 states. The new onboard strategy would require onboard for vehicles in all States except California, since much of the automobile refueling in California is already controlled by existing Stage II systems (approximately 90 percent of the California consumption and 9.5 percent of the nationwide consumption). Also, the Clean Air Act allows a State, such as California, to request a waiver from controls. This analysis assumes that the State of California would request (and be granted) a waiver from onboard controls, and would extend Stage II controls statewide. It is considered feasible to differentiate between vehicles destined for California and vehicles destined for the remainder of the country, since a distinction is already made for vehicles currently manufactured for sale in California due to stricter vehicle emission standards. Further, it is assumed that, in California, Stage II controls, incorporating size cutoffs consistent with those considered under other Stage II strategies (10/50 exemptions) and the present enforcement strategy resulting in a control efficiency of 86 percent, would be extended to all areas currently not controlled. Extending Stage II controls in California augments the existing State commitment to Stage II and would provide for emission and risk reduction similar to the onboard system. This new strategy is referred to as "Nationwide" or "49-State" onboard controls throughout this analysis. A discussion of the sensitivity of the analysis to the selection of 49-State or 50-State coverage is contained in Section 3.6 of Chapter 3.

The new onboard strategy also extends control coverage to several heavy-duty vehicle classes that were not included in the previous analysis, since it is now considered feasible to control such vehicles. Therefore, the new onboard strategy includes the cost, emission, and risk impacts associated with controlling most heavy-duty and all light-duty vehicles.

2.3.3.3 Excess Evaporative Controls. Several commenters felt that the reduction of excess evaporative emissions (excess evap) should be analyzed separately from the analysis of refueling emission control strategies. As a result of these comments, the Agency has developed a new control strategy that considers the reduction in excess evap primarily by enlarging the existing carbon canister presently used on vehicles to control evaporative emissions. This established a baseline against which the refueling options (Stage II and onboard) were analyzed, allowing a comparison of the control strategies in terms of refueling only. This new control strategy was considered not only separately, but also in combination with both nationwide and nonattainment area Stage II strategies. Since the new onboard control strategy controls both refueling and excess evaporative vapors, the Stage II and onboard strategies can therefore be evaluated on an equal basis.

The regulatory strategies were also evaluated as an increment to an existing excess evap control program. The results of this evaluation are presented in Section 3.3 of Chapter 3.

The excess evap control strategy, similar to the new onboard strategy, would require excess evaporative controls (enlargement of the existing carbon canister) on vehicles sold in 49 States. Again, California would be excluded from this strategy. California currently has implemented fuel volatility controls during the ozone season (Reid vapor pressure limited to 9.0 psi) that effectively reduce excess evaporative emissions.

2.3.3.4 Nonattainment Area Groupings. Various ozone nonattainment area groupings were evaluated to analyze both the impacts in areas where controls might be necessary and the effects of attributing various benefit levels to the control of emissions. In the July 1984 analysis, two nonattainment area groupings were evaluated for the impacts of Stage II controls. These were the all-nonattainment area grouping (designated "NA"), and certain nonattainment areas that had included a reference to Stage II in their SIP as an additional means of achieving necessary reductions in VOC emissions to provide for ozone attainment by 1987 (designated "NA*").

Under the new analysis, seven different nonattainment area groupings were evaluated. The first grouping consisted of 11 metropolitan areas with high ozone design levels and VOC shortfalls. The second grouping consisted of 27 areas in 21 States that were likely to continue to be nonattainment in 1987 and currently do not require Stage II. The third grouping consisted of all areas designated as nonattainment plus all urban areas with a design value greater than 0.10 ppm. (The "design value" is the fourth highest daily maximum 1-hour ozone concentration recorded during a 3-year period.) The fourth grouping consisted of all the designated urban and rural nonattainment areas. The fifth grouping consisted of only urban designated nonattainment areas and those rural areas considered to create their own ozone from sources within the area (self-generating areas). The sixth grouping consisted of 61 non-California areas that recorded design values greater than the ambient ozone standard (0.12 ppm) in 1982-1984.

Table 2-6 presents a summary of the characteristics of the various nonattainment area groupings. Appendix G contains nonattainment area data for each grouping, as indicated by an "x" in the Nonattainment Area Groups columns. Also included in Appendix G are county designations, population ranges, 1982 populations, and the 1982 gasoline throughputs assumed in the new analysis.

2.3.3.5 Stage II Exemption Levels. To respond to concerns expressed by several commenters regarding the exemption levels evaluated in the July 1984 document (<10,000 gallons/month for nonindependents, <50,000 gallons/month for independents), the new analysis considered two additional exemption levels (<10,000 gallons/month for all stations, and <2,000 gallons/month for all stations). Tables 2-7 and 2-8 present the results of this evaluation for the Stage II nationwide strategy, both for the 33-year analysis and in the year 2010. These tables show that exemption levels play an important role in the amount of emissions reduced, total costs, and cost effectiveness estimates. As expected, the lower

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Table 2-6. SUMMARY OF CHARACTERISTICS OF NONATTAINMENT AREA GROUPINGS FOR THE NEW ANALYSIS

Nonattainment Area Groupings (excluding California)	Throughput (10^6 gal/yr)	Population (millions)	% of U.S. Throughput	% of U.S. Population	Number of Counties
11 areas assumed to be nonattainment in 1987	15	43	15%	19%	59
27 areas assumed to be nonattainment in 1987	24	64	23%	28%	109
All areas designated as nonattainment plus all urban areas with a design value >0.10	58	140	56%	63%	427
All designated nonattainment areas (urban and rural)	52	130	51%	56%	365
All urban designated and rural self-generating nonattainment areas	47	120	46%	52%	240
61 Non-California areas with design values >0.12 in 1982-1984	36	94	35%	42%	270

Table 2-7. NATIONWIDE STAGE II CONTROL IMPACTS FOR VARIOUS EXEMPTION LEVELS[a] (33-YEAR ANALYSIS)

Regulatory Strategies (Without Evaporative Controls)	Average Annual Incidence Reduction (Bz + GV)[b]	Average Annual Emission Reduction of Gasoline Vapors, 10^3 Mg/yr	Annualized Costs, Including Enforcement, $ Million	Discounted Cost Effectiveness, $/Mg of VOC	Average Annual Enforcement Resources[c] Person-Years: $ Million
STAGE II NATIONWIDE (No size cutoffs)	32 - 46	230 - 340	410 - 500	1,610 - 2,050	680: $26
STAGE II NATIONWIDE (Ex. <2,000 gal/mo.)	31 - 45	230 - 330	320 - 390	1,300 - 1,660	500: $19
STAGE II NATIONWIDE (Ex. <10,000 gal/mo.)	29 - 42	210 - 310	200 - 240	860 - 1,110	250: $10
STAGE II NATIONWIDE (Ex. <10,000, <50,000 gal/mo.)	25 - 35	180 - 260	170 - 190	810 - 1,060	190: $7

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[a] Program efficiency reflects the range of efficiencies found between a program of minimal enforcement (62 percent) and an active (annual) enforcement program (86 percent) and the range of equipment phase-in schedules (3-7 years). If no range is indicated, the upper and lower values vary by less than 10 percent and the average is presented.

[b] GV = gasoline vapors (plausible upper limit rat data only). Benzene incidence reduction alone would represent about 10 percent of the total incidence reduction.

[c] Enforcement shown for annual 3-year phase-in enforcement only; minimal enforcement requires zero enforcement costs and resources. See Section 2.8 on enforcement impacts.

Table 2-8. NATIONWIDE STAGE II CONTROL IMPACTS FOR VARIOUS EXEMPTION LEVELS[a] (In Year 2010)

Regulatory Strategies (Without Evaporative Controls)	Annual Incidence Reduction (Bz + GV)[b]	Annual Emission Reduction of Gasoline Vapors, 10^3 Mg/yr	Annual Costs, Including Enforcement, $ Million	Cost Effectiveness, $/Mg of VOC
STAGE II NATIONWIDE (No size cutoffs)	36 - 50	260 - 370	520 - 580	1,580 - 1,990
STAGE II NATIONWIDE (Ex. <2,000 gal/mo.)	35 - 49	260 - 360	430	1,250 - 1,590
STAGE II NATIONWIDE (Ex. <10,000 gal/mo.)	33 - 46	240 - 330	260	800 - 1,050
STAGE II NATIONWIDE (Ex. <10,000, <50,000 gal/mo.)	28 - 39	200 - 280	210	750 - 990

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[a] Program efficiency reflects the range of efficiencies found between a program of minimal enforcement (62 percent) and an active (annual) enforcement program (86 percent) and the range of equipment phase-in schedules (3-7 years). If no range is indicated, the upper and lower values vary by less than 10 percent and the average is presented.

[b] GV = gasoline vapors (plausible upper limit rat data only). Benzene incidence reduction alone would represent about 10 percent of the total incidence reduction.

[c] Enforcement shown for annual 3-year phase-in enforcement only; minimal enforcement requires zero enforcement costs and resources. See Section 2.8 on enforcement impacts.

exemption cutoffs would provide better incidence and emission reduction, but at a higher cost. The new analysis also indicates that the exemption level of <10,000 gal/month for nonindependents and <50,000 gal/month for independents has the best cost effectiveness of the exemption levels analyzed. In addition, EPA's interpretation of Section 324 of the Clean Air Act may require the exemption of independents less than 50,000 gal/month. Therefore, the exemption level of <10,000 gal/month for nonindependents and <50,000 gal/month for independents is the primary assumption used in the comparison of Stage II impacts throughout this report. Other exemption level assumptions are also discussed later in the document. Where the exemption is not specifically stated, the basic 10/50 assumption is intended.

2.3.3.6 Number of Affected Facilities. Table 2-9 summarizes the number of affected facilities in each industry sector. Shown are the number of bulk terminals, storage tanks, for-hire tank trucks, bulk plants, and service stations used in the new analysis. No changes were assumed for bulk terminals, bulk plants, storage tanks, and for-hire tank trucks. The number of service stations affected is shown for the base year (1984).

2.3.3.7 Stage I with Stage II. In the July 1984 EPA analysis, Stage II nonattainment area strategies had included Stage I controls for those counties requiring Stage II controls but not yet having implemented Stage I. For this analysis, the Agency intended to more closely examine the comparison of onboard and Stage II as refueling control strategies. Therefore, the nonattainment analyses have excluded the potential impacts of Stage I controls in nonattainment areas. This allows a more direct comparison of Stage II and onboard as vehicle refueling control strategies.

2.4 ENVIRONMENTAL AND ENERGY IMPACTS

Many changes have been made in the new analysis that affect the calculation of the emission reduction impacts associated with the regulatory strategies. Most of these changes have already been discussed previously in this chapter. In this section, the changes to the calculations will be discussed.

Table 2-9. NUMBER OF AFFECTED FACILITIES ASSUMED IN THE NEW COST ANALYSIS

Facility Type	Percent Consumption Controlled at Steady State	Total Facilities Affected	Number of Facilities in Each Model Plant (MP) Size				
			MP 1	MP 2	MP 3	MP 4	MP 5
BULK TERMINALS	100	500[a]	240	135	105	20	NA
BULK PLANTS							
- Exempt Bulk Plants < 4,000 gpd	14.9	8,040[b,c]	3,400	4,000	560	80	NA
SERVICE STATIONS							
NATIONWIDE ALTERNATIVES							
Stage I							
- Exempt Stations < 10,000 gal/mo	34.6	61,300	--	24,900	21,900	11,700	2,800
Stage II							
- Exempt Stations < 10,000 gal/mo and Independent Stations < 50,000 gal/mo (Independents Only)	69.4	108,400	--	42,800	31,500	27,500 (9,300)	6,600 (2,300)
NONATTAINMENT AREA ALTERNATIVES							
Stage II							
- Exempt Stations < 10,000 gal/mo and Indendent Stations < 50,000 gal/mo (Independents Only)							
11 Areas	14.6	23,100		9,100	6,700	5,900 (2,000)	1,400 (490)
27 Areas	17.7	27,900	--	11,000	8,100	7,100 (2,400)	1,700 (600)
61 Areas	27.2	42,900		16,900	12,500	10,900 (3,700)	(2,600) (900)
FIXED ROOF STORAGE TANKS[d]	NA						
TANK TRUCKS							
- For-hire Terminal Trucks	NA	5,800[a]	--	--	--	--	--
- For-hire Bulk Plant Trucks (< 4,000 gpd BP Exempt)	NA	9,400[c]	--	--	--	--	--

[a] Bulk terminal affected facilities include about 2,870 terminal-owned trucks.

[b] Bulk plants with throughput <4,000 gal/day will be required to use submerged fill on outgoing loads (account trucks).

[c] Bulk plant affected facilities under the with-exemption option include 9,300 plant-owned trucks requiring vapor balance and 6,700 plant-owned trucks requiring only submerged fill. An additional 6,900 for-hire trucks would require submerged fill.

[d] Includes only fixed-roof storage tanks at bulk terminals to be retrofitted with internal floating roofs. The two fixed-roof tanks assumed per bulk plant cannot be retrofitted with internal floating roofs since floating roofs are not compatible with vapor balancing.

2.4.1 Air Emissions

2.4.1.1 Baseline Emissions. Baseline emissions are the level of pollutant emissions under existing regulations in the absence of further emission standards, assuming the existing regulations are enforced. As in the 1984 analysis, the throughput occurring within each industry segment was matched to the appropriate composite emission factor dictated by existing State and local regulations. These were multiplied together to yield estimates of baseline VOC emissions. However, several changes were made in the new analysis that affected these estimates. First, the base year was adjusted from 1982 to 1984, to reflect the latest information available at the time the reanalysis began. In addition, errors found in the control levels assumed for States or parts of States were corrected, the baseline throughput was updated to 1984, and the specific throughput for one State (Maryland) was adjusted to respond to comments. The biggest change to the emission baseline, however, was due to the changes made to the emission factors to reflect changes in emission formulas and assumptions (discussed in Section 2.1). Different emission factors were used, depending on whether the analysis was for nationwide alternatives or for nonattainment area alternatives (see Table 2-2). Taking these changes into consideration and using the same basic methodology as in the 1984 analysis, the baseline emissions were recalculated and are presented in Appendix F. Table 2-10 presents a summary of the revised baseline emission estimates.

2.4.1.2 Regulatory Strategy Emission Reductions. As in the July 1984 analysis, the emission reductions calculated in the base year for Stage I and Stage II strategies were projected for each year into the future in proportion to the change in gasoline consumption to estimate future emission reductions. In the new analysis, the gasoline consumption projections in Table 2-4 were used. Onboard emission reductions were calculated for each year based on the gasoline consumption of controlled vehicles shown in Table 2-11. Excess evaporative emission reductions were calculated each year based on the vehicle miles travelled by controlled vehicles shown in Table 2-12. These new projections in Tables 2-11 and 2-12 were obtained from EPA's MOBILE3 Fuel Consumption Model (I-A-99, I-B-37). As in the July 1984 analysis, control options were first considered for each source category in the gasoline marketing

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Table 2-10. BASELINE VOC EMISSIONS ASSOCIATED WITH THE NEW ANALYSIS

Emission Category	VOC Emissions, 10^3 Mg/yr					
	NATIONWIDE				NONATTAINMENT AREAS	
	1984 Annual Emissions	1988 - 2020 Avg. Annual Emissions	1988 - 2020 Annualized Emissions	2010 Annual Emissions	1984 Annual Emissions 27 Areas	1984 Annual Emissions 61 Areas
Bulk Terminals[a]	240	200	220	190	45	85
Bulk Plants	170	140	160	140	33	60
Service Stations						
Storage Tanks	240	200	220	190	45	85
Vehicle Refueling	530	440	500	430	99	180
Vehicle Operations						
Excess Evap[b]	NC	300	220	380	NC	NC

[a] Includes both loading rack and storage tank emissions.

[b] Only excess evap that is not currently controlled and is controllable by increasing the size of the existing canister system.

NC = not calculated.

Table 2-11. GASOLINE CONSUMPTION PROJECTIONS FOR CONTROLLED VEHICLES

GASOLINE CONSUMPTION BY CONTROLLED VEHICLES (10**9 liters/year)

Year	July 1984 Analysis		New Analysis	
	No Tampering	With Tampering	No Tampering	With Tampering
1988	33	32	0	0
1989	62	60	0	0
1990	87	84	37	37
1991	110	105	70	69
1992	131	124	99	97
1993	148	140	124	122
1994	164	153	146	143
1995	177	165	164	161
1996	189	175	181	176
1997	198	182	195	190
1998	206	189	208	202
1999	213	195	219	212
2000	218	199	229	221
2001	223	203	238	230
2002	225	207	245	237
2003	227	210	252	243
2004	229	211	257	248
2005	230	212	261	252
2006	231	212	264	254
2007	231	212	266	256
2008	231	212	268	258
2009	231	212	269	259
2010	231	212	270	260
2011	231	212	270	260
2012	231	212	270	260
2013	231	212	271	261
2014	231	212	271	261
2015	231	212	271	261
2016	231	212	271	261
2017	231	212	271	261
2018	231	212	271	261
2019	231	212	272	261
2020	231	212	272	262

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Table 2-12. VEHICLE MILES TRAVELED (VMT) PROJECTIONS FOR CONTROLLED VEHICLES

VMT - NO TAMPERING (10**9 miles/year)

	July 1984 Analysis	New Analysis			
Year	Total	Total (a)	LDV	LDT	HDGV
1988	207	0	0	0	0
1989	399	0	0	0	0
1990	577	213	159	47	8
1991	746	406	304	88	14
1992	906	580	436	123	20
1993	1,051	735	556	154	25
1994	1,181	873	664	179	30
1995	1,299	995	760	201	34
1996	1,407	1,105	847	220	38
1997	1,491	1,206	926	238	41
1998	1,571	1,298	999	255	44
1999	1,630	1,382	1,065	270	47
2000	1,686	1,457	1,124	283	50
2001	1,686	1,524	1,176	296	52
2002	1,686	1,584	1,222	308	54
2003	1,686	1,637	1,262	318	57
2004	1,686	1,684	1,298	328	59
2005	1,686	1,730	1,329	338	60
2006	1,686	1,762	1,355	345	62
2007	1,686	1,795	1,379	353	64
2008	1,686	1,827	1,402	359	65
2009	1,686	1,856	1,424	366	67
2010	1,686	1,884	1,445	371	68
2011	1,686	1,911	1,465	377	69
2012	1,686	1,936	1,484	382	70
2013	1,686	1,962	1,504	387	72
2014	1,686	1,988	1,524	392	73
2015	1,686	2,014	1,543	397	74
2016	1,686	2,041	1,563	403	75
2017	1,686	2,066	1,583	407	76
2018	1,686	2,092	1,602	413	77
2019	1,686	2,118	1,622	418	78
2020	1,686	2,145	1,642	423	80

(a) Values may not add up to shown totals due to rounding.

Table 2-12. VEHICLE MILES TRAVELED (VMT) PROJECTIONS FOR CONTROLLED VEHICLES (Concluded)

VMT - WITH TAMPERING (10**9 miles/year)

	July 1984 Analysis	New Analysis			
Year	(Total)	Total	LDV	LDT	HDGV
1988	203	0	0	0	0
1989	388	0	0	0	0
1990	558	212	159	46	8
1991	717	402	302	86	14
1992	864	573	433	120	20
1993	997	724	550	150	25
1994	1,113	857	654	174	29
1995	1,218	974	746	195	33
1996	1,312	1,080	830	213	37
1997	1,381	1,176	905	230	40
1998	1,447	1,263	974	246	43
1999	1,502	1,342	1,036	260	46
2000	1,544	1,413	1,091	273	48
2001	1,544	1,476	1,141	285	50
2002	1,544	1,532	1,184	296	53
2003	1,544	1,583	1,222	306	55
2004	1,544	1,627	1,255	315	56
2005	1,544	1,666	1,284	324	58
2006	1,544	1,700	1,309	332	60
2007	1,544	1,732	1,332	339	61
2008	1,544	1,762	1,354	345	63
2009	1,544	1,790	1,375	351	64
2010	1,544	1,817	1,395	356	65
2011	1,544	1,843	1,415	362	67
2012	1,544	1,867	1,433	366	68
2013	1,544	1,892	1,452	371	69
2014	1,544	1,917	1,471	376	70
2015	1,544	1,942	1,490	381	71
2016	1,544	1,967	1,509	386	72
2017	1,544	1,993	1,528	391	73
2018	1,544	2,018	1,547	396	74
2019	1,544	2,043	1,566	401	76
2020	1,544	2,068	1,585	406	77

industry. Table 2-13 presents the revised nationwide emission reductions associated with these control options. The various regulatory strategies are in turn composed of particular control options for each source category. Table 2-14 presents the revised nationwide emission reductions for nine regulatory strategies. These tables are similar to Tables 5-7 and 5-9 presented in the July 1984 document (I-A-55). However, emission reductions for ethylene dibromide (EDB) and ethylene dichloride (EDC), contained only in leaded gasoline, were not included because the emission reductions and risks associated with EDB and EDC were found to be extremely small compared to benzene and gasoline vapors, and because the expected accelerated leaded gasoline phase-down will further decrease the impacts from EDB and EDC.

The values for Stage II shown in Tables 2-13 and 2-14 are presented in a range to reflect the range of in-use efficiencies that can be expected and the range of phase-in rates that were analyzed. The ranges, which represent worst-case to best-case assumptions, are as follows:

		Nationwide Strategies	Nonattainment Area Strategies
Low End of Range	-	Minimal enforcement; API (7-year) phase-in	Minimal enforcement; high difficulty (5-1/2 year) phase-in
High End of Range	-	Annual enforcement; statutory (3-year) phase-in	Annual enforcement; low difficulty (3-year) phase-in

Other changes included in the emission reduction calculations and discussed in Section 2.3.3 are:

- use of the new designated areas for nonattainment strategies;
- use of the new start dates for the regulatory strategies, thereby changing the net present value analysis;
- use of only an 8-year combination of Stage II with onboard, with emission reductions ending after 8 years;
- calculation of emission reductions for excess evaporative controls and strategies that incorporate evaporative controls;
- calculations for a 49-State onboard analysis (no onboard in California, extend Stage II to all stations in California), addition of controls for heavy-duty vehicles, and addition of excess evaporative impacts.

Table 2-13. NATIONWIDE EMISSION REDUCTIONS ASSOCIATED WITH GASOLINE MARKETING CONTROL OPTIONS (1988-2020)

Facility Type (with Size Exemptions)	Emission Reductions (10^3 Mg/yr)					
	Gasoline Vapors			Benzene		
	Average[a] Annual	Annualized[b]	2010[c]	Average[a] Annual	Annualized[b]	2010[c]
o Stage I						
Bulk Terminals						
- Loading Racks	75	69	81	0.4	0.4	0.4
- Storage Tanks	29	26	32	0.2	0.1	0.2
Bulk Plants	83	76	90	0.4	0.4	0.5
Service Stations (Stage I)						
- Nationwide	120	110	130	0.6	0.6	0.7
o Vehicle Refueling						
Stage II[d]						
- Nationwide	180-260	160-230	200-280	1.2-1.4	1.1-1.2	1.4-1.5
- 61 Areas	66-100	54-110	77-110	0.4-0.5	0.4-0.6	0.5-0.6
- 27 Areas	43-67	35-70	50- 69	0.2-0.3	0.2-0.4	0.3
- 11 Areas	28-44	23-45	32- 44	0.1-0.2	0.1-0.2	0.2
Onboard[e]	530	380	680	4.2	3.0	5.5
o Excess Evaporative[f]	250	180	330	2.8	1.9	3.6

[a] Average Annual = cumulative divided by 33.

[b] Annualized = 1988 Net Present Value of emissions reannualized over 1988-2020 to a stream of constant values.

[c] 2010 = Estimated emission reductions in the year 2010.

[d] Range of values represents the range of efficiencies found between a program of minimal enforcement and an active (annual) enforcement program. For nationwide strategies, the range is from minimal enforcement (7-year phase-in), to annual enforcement (3-year phase-in). For nonattainment area strategies, the range is from minimal enforcement, high-difficulty phase-in to annual enforcement, low-difficulty phase-in. If no range is indicated, the upper and lower values vary by less than 10 percent and the average is presented.

[e] Includes excess evaporative emission reduction benefits.

[f] Excess evaporative emissions controllable by enlarging the existing carbon canister.

Table 2-14. NATIONWIDE EMISSION REDUCTIONS ASSOCIATED WITH GASOLINE MARKETING REGULATORY STRATEGIES (1988-2020)

Regulatory Strategy (with Size Exemptions)	Emission Reductions (10^3 Mg/yr)					
	Gasoline Vapors			Benzene		
	Average Annual[a]	Annualized[b]	2010[c]	Average Annual[a]	Annualized[b]	2010[c]
Stage I - Nationwide	310	280	340	1.6	1.4	1.7
Evaporative Controls[f]	250	180	330	2.8	1.9	3.6
Stage II - 27 Areas[d]	43-67	35-70	50-69	0.2-0.3	0.2-0.4	0.3
Stage II - 27 Areas[d], Plus Evaporative Controls	290-320	210-250	380	3.1	2.1-2.3	3.9
Stage II - Nationwide[d]	180-260	160-230	200-280	1.2-1.4	1.1-1.2	1.4-1.5
Stage II - Nationwide,[d] Plus Evaporative Controls	430-510	330-410	530-610	4.0	3.0	5.0
Onboard Nationwide[e]	530	380	680	4.2	3.0	5.5
Stage II - 27 Areas[d], Plus Onboard Nationwide[e]	540	400	680	4.2	3.1	5.5

[a] Average Annual = cumulative divided by 33.

[b] Annualized = 1988 Net Present Value of emissions reannualized over 1988-2020 to a stream of constant values.

[c] Emission reduction estimates in the year 2010.

[d] Range of values represents the range of efficiencies found between a program of minimal enforcement and an active (annual) enforcement program. For nationwide strategies, the range is from minimal enforcement (7-year phase-in) to annual enforcement (3-year phase-in). For nonattainment area strategies, the range is from minimal enforcement, high-difficulty phase-in to annual enforcement, low-difficulty phase-in. If no range is indicated, the upper and lower values vary by less than 10 percent and the average is presented.

[e] Includes excess evaporative emission reduction benefits.

[f] Excess evaporative emissions controllable by enlarging the existing carbon canister.

To further illustrate the comparison of Stage II and onboard emission reductions, Figures 2-4, 2-5, and 2-6 depict the emissions associated with these strategies with time. All of these figures are based on the 10/50 exemption level discussed in Section 2.3.3.5. In each figure, emissions are compared with a projection of baseline or no further controls, and a percentage of emissions reduced is indicated. Figure 2-4 illustrates the information for refueling emissions only. Figure 2-5 includes emptying losses (most of which Stage II will control) in the baseline. Figure 2-6 includes emptying losses and spillage emissions in the baseline. Spillage emissions occur during refueling; however, neither Stage II nor onboard controls will reduce spillage emissions, so no spillage emission reduction was assumed for either Stage II or onboard.

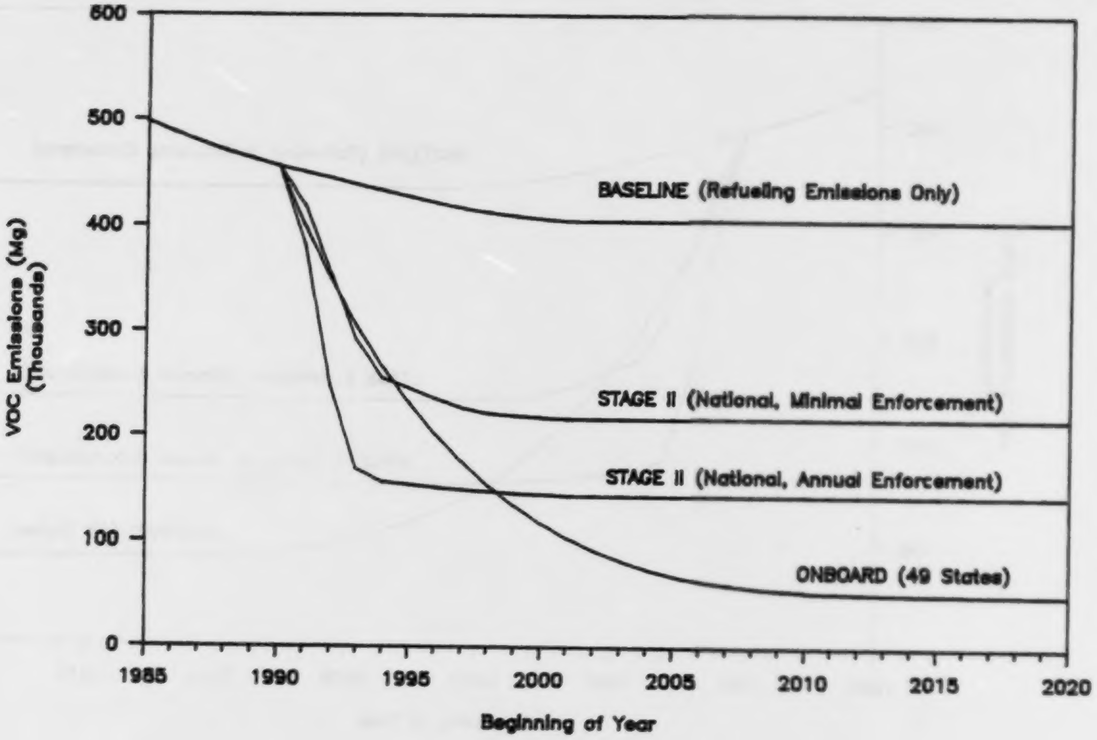
2.4.2 Fuel Savings

In addition to the emission reduction impacts, the fuel savings impacts were revised in the new analysis. The largest impact on the fuel savings calculations came from the adjustment of the emission factors. In addition, the July 1984 analysis had no fuel savings credits associated with the onboard strategy. Under the new analysis, recovery credits are included for onboard; therefore, fuel savings credits are also included. Table 2-15 presents the fuel savings associated with the gasoline marketing regulatory strategies calculated under the new analysis. Included in Table 2-15 are the fuel savings impacts that correspond to the excess evaporative strategy and those strategies in combination with excess evaporative controls.

2.5 COST ANALYSIS

The basic methodology for estimating costs did not vary significantly between the 1984 analysis and the new analysis. However, changes or adjustments were added to reflect the changes to the analysis. For instance, recovery credits were changed to reflect the updated emission estimates, and service station costs were updated to reflect service station facility projections and updated per-facility costs. The purpose of this section is to outline all the changes made to the gasoline marketing cost analysis.

Figure 2-4. VOC EMISSIONS 1985–2020



PERCENT EMISSION REDUCTION 1985–2020

Of Refueling Emissions Only

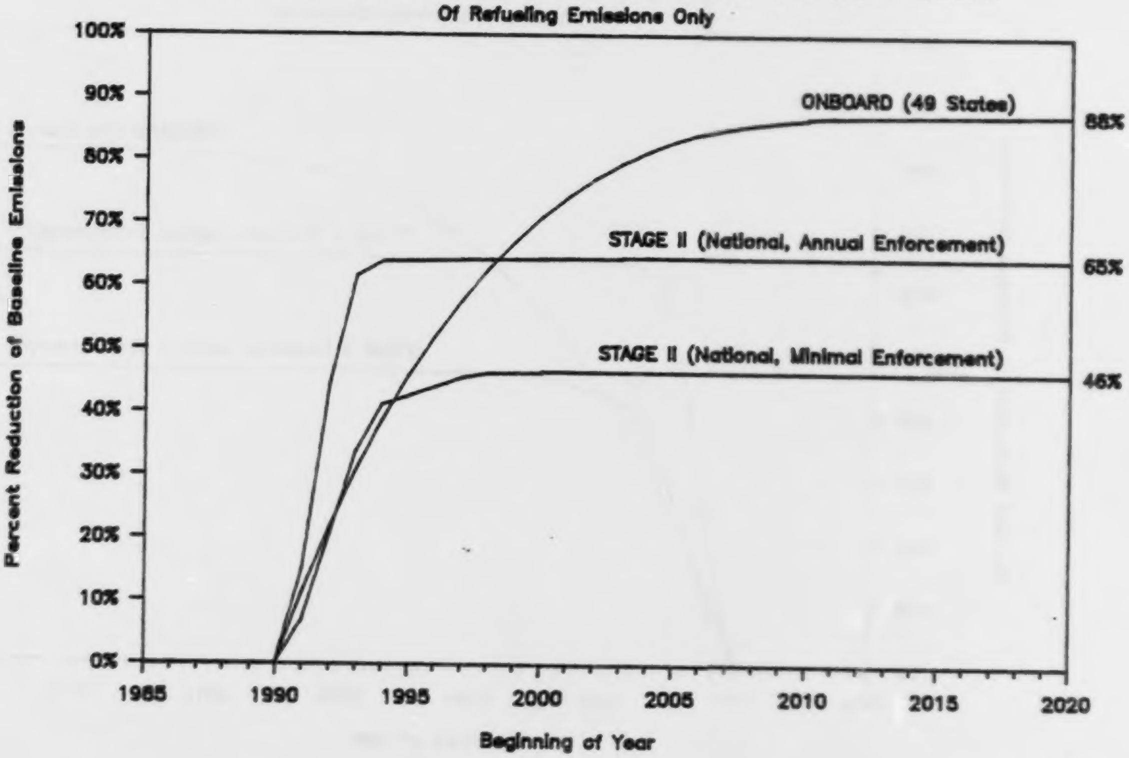
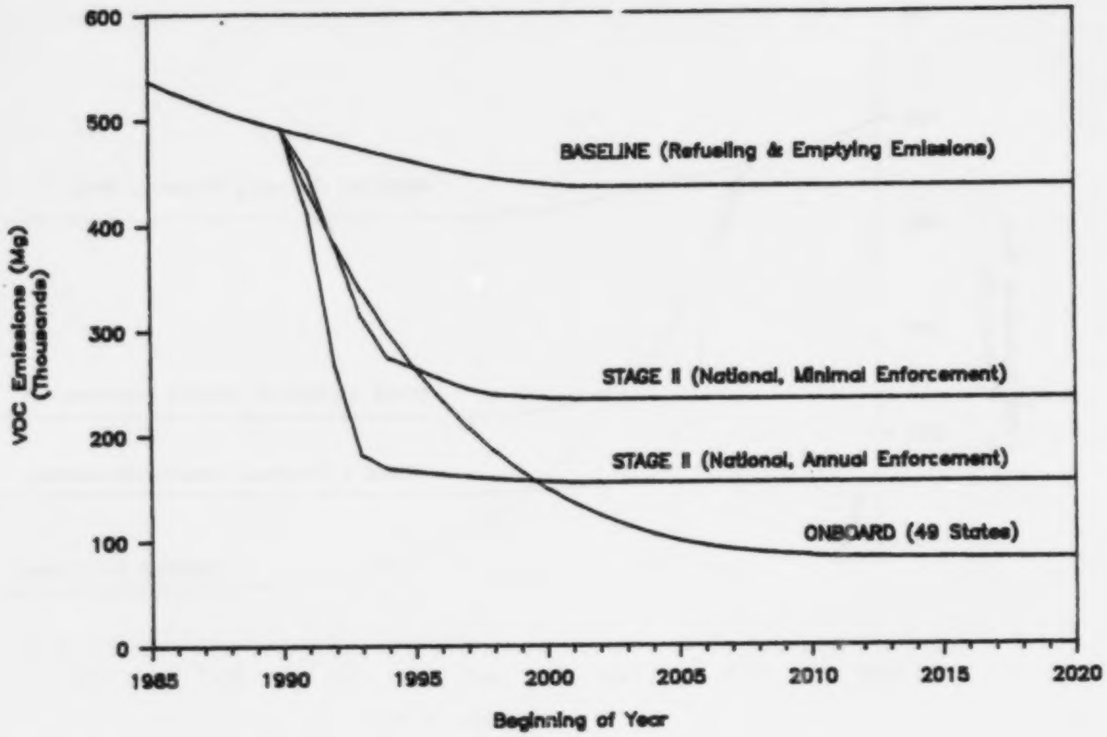


Figure 2-5. VOC EMISSIONS 1985–2020



PERCENT EMISSION REDUCTION 1985–2020

Of Refueling & Emptying Emissions

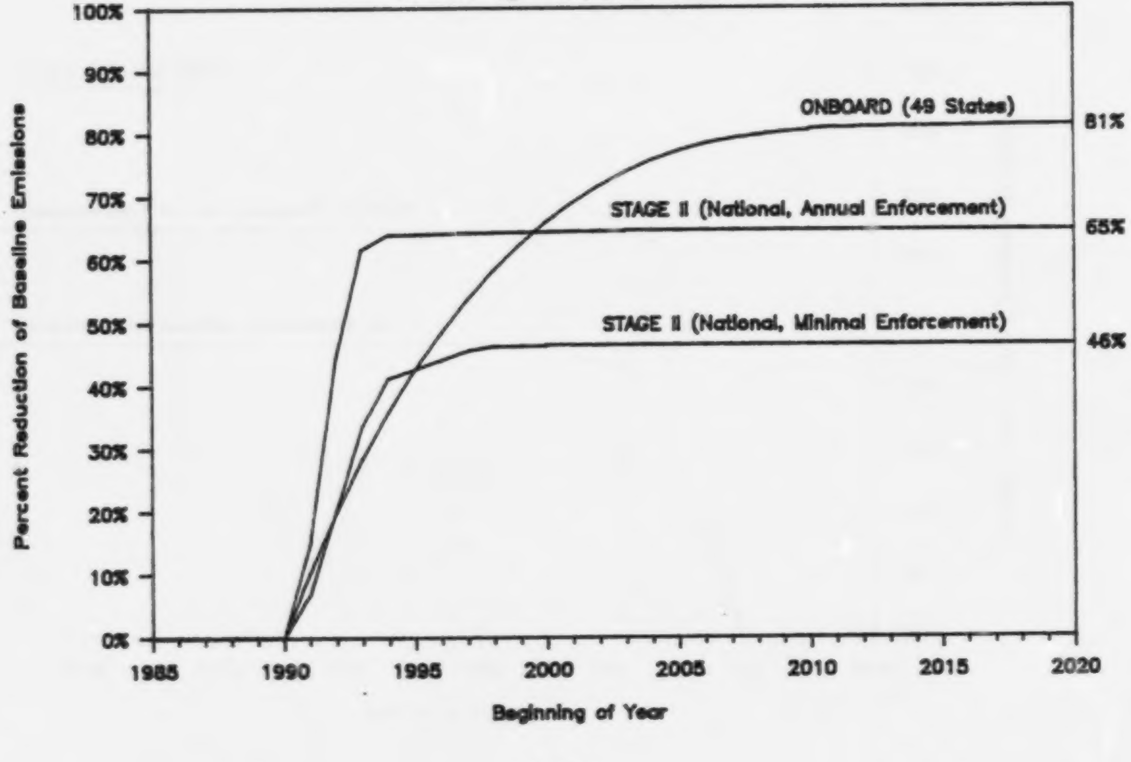
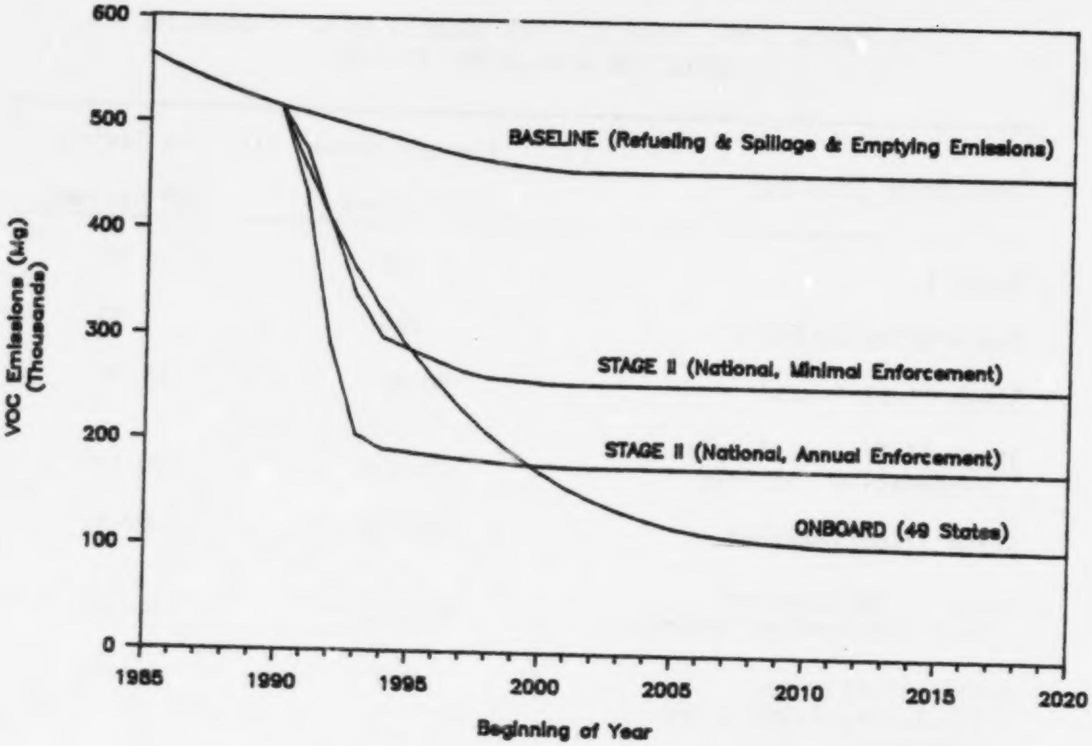


Figure 2-6. VOC EMISSIONS 1985–2020



PERCENT EMISSION REDUCTION 1985–2020

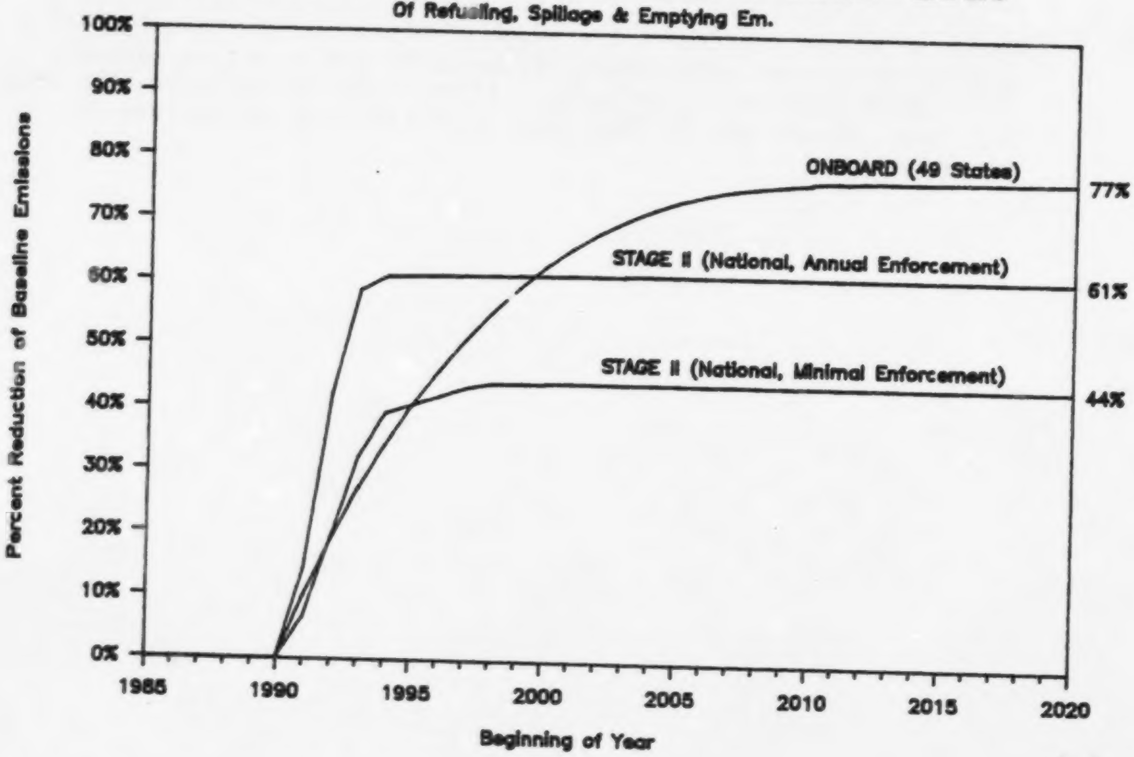


Table 2-15. FUEL SAVINGS ASSOCIATED WITH GASOLINE MARKETING REGULATORY STRATEGIES

Regulatory Strategy	Average Annual Gasoline Savings	
	10^6 Liters	10^6 Gallons
Stage I	150	40
Evaporative Controls	320	80
Stage II-27 Areas[a]	60-90	15-20
Stage II-27 Areas[a], plus Evaporative Controls	370-410	100-110
Stage II-Nationwide[a]	230-330	60-90
Stage II-Nationwide[a] plus Evaporative Controls	550-650	150-170
Onboard Nationwide (Including Evaporative Controls)	610	160
Stage II-27 Areas[a], plus Onboard Nationwide	620	160

[a] Range of values represents the range of efficiencies found between a program of minimal enforcement (62 percent) and an active (annual) enforcement program (86 percent). If no range is indicated, the upper and lower values vary by less than 10 percent and the average is presented.

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2.5.1 Recovery Credits

In general, all recovery credit values for each industry sector were adjusted for the new analysis to reflect the change in RVP used in the emission estimates. In most cases the emission estimates increased; therefore, the associated recovery credits increased. A change in the calculation of recovery credits for service stations using Stage II systems was made based on a revised view of tank emptying losses. In the 1984 analysis, it was assumed that 50 percent of the potential underground tank breathing losses, or 60 mg/liter, would be recovered. It is assumed in the new analysis that all of these losses, or 120 mg/liter, can be considered emptying losses and are controlled at the efficiency of the Stage II system.

A change has also been made in the gasoline recovery credit attributed to the Stage II regulatory strategies to account for an energy penalty. This penalty represented the decreased energy content of gasoline stored at a station with a Stage II system, since the Stage II system reduces evaporation in the underground tank, causing the product to retain "light ends." A gallon of product with the light ends retained has about 14 percent less energy content than a gallon of gasoline composed predominantly of heavier ends ("weathered product"). The recovery credit for Stage II, therefore, was reduced by 14 percent since more product is required in order for the customer to realize the same total energy content. Stage II recovery credits were also changed to reflect the latest in-use efficiencies discussed in Section 2.2.2 and Appendix A.

Under the new analysis, gasoline excise taxes were analyzed to determine if these taxes should be included in the value assigned for recovery credit calculations. Gasoline excise taxes are, in part, payments to factors of production, since some of the tax receipts are spent to facilitate the production, distribution, and consumption of gasoline. Gasoline taxes also are, in part, transfer payments, since some of the tax receipts are spent in areas that have no direct effect on the production, distribution, and consumption of gasoline. The cost to society of an EPA regulation is composed of payments to factors of production; the cost to society does not include transfer payments. Similarly, regulatory benefits--in this case recovery credits--should reflect savings in the payments to factors of production, but not savings in transfer payments. Thus, only a portion of gasoline excise taxes should enter into recovery credits.

Unfortunately, there is no accepted procedure to divide excise taxes into the two unambiguous and non-overlapping categories of factor payments and transfer payments. For this reason, EPA has elected to treat the taxes as transfer payments for calculating the costs and benefits of the regulatory strategies to society. This has the effect of reducing recovery credits, which increases the computed costs of the regulatory strategies.

Costs and benefits to society usually are not computed the same way as costs and benefits to individual firms. Firms do not consider changes in tax-supported services when they make production, pricing, employment, and related decisions. Firms look at their own balance sheets--not society's. For this reason, EPA's analysis of price and quantity changes includes full consideration of excise taxes. Specifically, excise taxes are included in the recovery credits that are considered by service stations in raising gasoline prices, because station owners pay these taxes when they buy gasoline.

Given that there are two ways of treating gasoline excise taxes, the unit price for recovery credits at the various gasoline marketing facilities was estimated. These estimates are discussed below and the prices used in the analysis are shown in Table 2-16. Table 2-17 gives the data sources for and derivation of these estimates.

For the onboard control system analysis, the recovery credits are realized by the vehicle owner. Refueling vapors, normally lost to the atmosphere, are collected in the carbon canister and later burned in the engine. The vehicle owner is getting the energy benefit of these vapors and saving money by purchasing less fuel. The price of gasoline used in the market adjustment analysis for onboard control is therefore the price of the fuel that the vehicle owner would have to pay, or the full retail price. The analysis of costs to society uses the retail price less taxes (transfers).

For the Stage II control system analysis, the recovery credits are realized by the service station owner. Refueling vapors, which are nearly saturated, are captured and returned to the vapor space of

Table 2-16. FACILITY RECOVERY CREDIT GASOLINE PRICES

Facility	Recovery Credit Gasoline Price ($/gal) used in: Social or Economic Analysis*	Recovery Credit Gasoline Price ($/gal) used in: Market Adjustment Analysis
Vehicle Refueling		
- Onboard Controls	0.98	1.20
- Stage II Controls	0.91	1.13
Bulk Plants	0.87	1.09
Bulk Terminals	0.81	1.03

*Does not include $0.22/gal taxes ($0.13/gal State excise tax and $0.09/gal Federal tax).

Table 2-17. DERIVATION OF RECOVERY CREDIT GASOLINE PRICES
(3rd Quarter 1984 Dollars)

Item	Price/Cost	Reference
Retail Gasoline Price	$1.20/gal	Department of Energy Monthly Energy Review, March 1985, as reported in the 1985 NPN Factbook, Mid-June 1985, p. 101 (I-F-133).
Taxes	22 cents/gal [Net Gasoline Price $0.98/gal]	State tax of 13 cents per gallon from EPA model that consumption-weights State excise and sales tax by State, plus 9 cents Federal tax.
Service Station Margin	7 cents/gal [Net Gasoline Price $0.91/gal]	Average of 1979 through 1982 margins. From Table 5-4, Preliminary Economic Impact Assessment of Regulatory Strategies to Control Emissions from Gasoline Marketing Industry, August 1984 (I-A-57).
Bulk Plant Margin	4 cents/gal [Net Gasoline Price $0.87/gal]	Derived from recent survey of bulk plant operators conducted for EPA under Volatile Organic Liquid Storage standard development, March 1984.
Transportation Costs	2 cents/gal [Net Gasoline Price $0.85/gal]	$0.004/Liter from Table 8-55, Bulk Terminal BID Vol. I, December 1980 (I-A-34), and updated to current costs by ratio of 1984/1979 wholesale gasoline prices (78/57) from p. 101, 1985 NPN Factbook.
Bulk Terminal Margin	4 cents/gal [Net Gasoline Price $0.81/gal]	4.5% before-tax profit margin from Table 8-55, Bulk Terminal BID Vol. I, December 1980. Multiplied by reported wholesale cost and updated to 1984 by using wholesale price ratio (78/57).

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the underground storage tank. By returning saturated vapors to the vapor space (instead of the normal situation where air is drawn into the tank through vent lines), product evaporation in the tank is reduced and, therefore, the station owner has to purchase less product. Consequently, the price of gasoline used in the Stage II analysis is based on the price the service station operator pays for gasoline, or the retail price minus the owner's mark-up or margin.

For Stage I, the recovery credits for bulk plant and storage tank operations are based on the same evaporation principles as those discussed for service stations (the reduction in product loss due to evaporation). However, at bulk terminals there is control equipment available that captures vapors from the trucks being loaded and recovers the vapors as liquid product. For bulk terminals, bulk plants, and storage tanks the price of gasoline must exclude not only the service station dealer markup, but also their delivery and facility mark-ups.

As a check on the estimated margins, the final terminal cost ($0.81/gal) was compared to published refinery gasoline prices for 1984. However, before the price can be compared directly with refinery prices, an additional transportation cost (2 cents/gal) must be included for the transportation costs from the refinery to the terminal. Backing this value out yields a refinery price of $0.79/gal. This compares very closely to a published 1984 refinery price of $0.81/gal (I-F-133).

2.5.2 Model Plant Costs

In addition to the value of recovery credits, several revisions were made to the individual facility cost estimates to correct errors and to respond to comments. All costs in the 1984 analysis were based on a base year of 1982. Unless specifically corrected, these costs were updated to a 1984 base year by the use of cost indices (I-F-79, I-F-112). The tables presenting the model plant costs used in the new analysis are presented in Appendices B and J for direct comparison to the 1984 analysis. The following paragraphs discuss the major changes in the model plant costs.

2.5.2.1 Bulk Terminals. In response to comments, changes were made to the assumptions concerning top loading of tank trucks at existing bulk gasoline terminals. One commenter felt that many additional top-to-bottom loading conversions would be required under a nationwide

Stage I requirement. In the July 1984 analysis, it was assumed that 10 percent of the uncontrolled terminals currently practiced top loading and would convert to bottom loading. After re-evaluating data received by the Agency under the development of New Source Performance Standards for bulk gasoline terminals, the assumed percentage of terminals that would convert from top to bottom loading was changed from 10 percent to 60 percent. This increased the estimated capital costs associated with controlling terminals by about 25 percent.

Also changed for the bulk terminal model plants were the capital costs associated with carbon adsorption vapor recovery systems. These costs were changed to reflect current capital costs supplied by one equipment vendor (I-H-27). This new cost represented a 20 percent decrease for this vendor's equipment from the value shown in the 1984 analysis.

2.5.2.2 Bulk Plants. In the new analysis, an error was corrected in the calculation of product recovery credits applied to bulk plants. The recovery credit associated with the reduction of bulk plant storage tank emptying losses was not considered in the 1984 analysis. However, the recovery credits for bulk plant operations are based on the same principles as those applying to service stations (reduced evaporation and loss of stored product due to vapor transfer). Since recovery credits were taken for reduction in underground storage tank emptying losses at service stations, they should also apply for bulk plants, and they have been included in the new analysis.

2.5.2.3 Service Stations. Considerable changes were made in the per-facility cost analysis for the service station industry sector. A much more detailed per-facility cost analysis was added to the new calculations. The analysis was based on systems currently certified in California and contains specific costs for dispenser modification hardware, trenching costs, piping costs, and labor costs. Appendix B describes, in detail, the methodology used in estimating the Stage II per-facility costs. These updated per-facility costs also reflect the changes made to the fuel RVP, dispenser configurations, emission factors, fuel costs, and inuse efficiencies discussed earlier. Table 2-18 presents a comparison of capital and annual costs between the July 1984 analysis and the new analysis. In addition, revised Stage II capital cost estimates are presented for a 35,000 gal/month service station in Table 2-19. The selection of the above "typical" station

Table 2-18. WEIGHTED AVERAGE STAGE II COSTS[a]
(Retrofit of Existing Stations)

Model Plant[b]	Previous Analysis Capital Cost, $	Previous Analysis Annual Cost, $	New Analysis Capital Cost, $	New Analysis Annual[c] Cost, $
1	5,700	1,400	5,700	1,300[d]
2	6,100	1,300	7,300	1,400
3	6,600	1,300	12,200	2,500
4	9,800	1,400	16,100	3,200
5	14,800	500	23,200	3,100

[a] Weighted average - 80 percent balance systems, 15 percent hybrid systems, 5 percent vacuum assist systems.

[b] See Section 2.3.1 for a description of the model plant parameters.

[c] Annual costs reflect annual enforcement.

[d] For purposes of comparing previous and new analysis, table based on same Model Plant 1 throughput.

Table 2-19. COMPARISON OF STAGE II COST ESTIMATES FOR NEW AND EXISTING MODEL PLANT 3[a] SERVICE STATIONS ($)

Type of System	Existing Facility Capital Cost, $	Existing Facility Annual[b] Cost, $	New Facility Capital Cost, $	New Facility Annual[b] Cost, $
Balance	11,900	2,470	6,540	1,740
Hybrid	12,600	2,690	6,940	1,880
Vacuum Assist	15,400	3,470	10,190	2,760
Weighted Avg.	12,200	2,550	6,780	1,810

[a] Model Plant 3 has a throughput range of 25,000 to 50,000 gallons per month.

[b] Annual costs reflect installation and vapor recovery cost under an annual enforcement program.

was based upon a throughput weighted average of stations that would require controls with a 10/50 exemption level. Again, a complete description of the costs associated with each major type of Stage II system is contained in Appendices B and J.

The service station Model Plant 1 was divided into two categories, one to represent public service stations (6,000 gal/month) and one to represent private service stations (2,000 gal/month) (see more detailed discussion in Section 2.3.1). Costing for each of these model plants was handled separately. The physical equipment was considered the same at each facility, but the annualized cost differed because the throughputs and resultant recovery credits differed for each model plant.

2.5.2.4 Onboard Unit Costs. The new J-tube onboard technology also affected the per-vehicle costs. Table 2-20 contains a breakdown of the per-vehicle onboard hardware costs used in the July 1984 document and the per-vehicle costs used in the new analysis. The new analysis costs are derived and explained in detail in Chapter 2 of the document, "Evaluation of Air Pollution Regulatory Strategies for Gasoline Marketing Industry -- Response to Public Comments," referenced in Chapter 1 of this document. The costs in Table 2-20 include the control of excess evaporative emissions and represent the initial onboard system costs. In the July 1984 analysis, the costs throughout the study period did not change from the initial $13.32 for light-duty vehicles (LDV) and $18.19 for light-duty trucks (LDT). For the new analysis, the costs change with time to reflect lower costs after recovering initial engineering, research, and development costs, and to reflect the smaller carbon canisters needed for smaller fuel tanks on future higher mileage vehicles projected by the MOBILE3 model (see footnote e in Table 2-20). In addition, the new analysis expands onboard coverage to include heavy-duty gasoline vehicles (HDGV) and, therefore, incorporates costs for onboard controls on heavy-duty vehicles.

Projections of cost impacts for the onboard strategy in the new analysis were based on revised projections of new vehicle registration and of vehicle miles traveled by vehicles equipped with onboard controls. Table 2-12 contained the projections for vehicle miles traveled; Table 2-21 contains the projections for vehicle registrations. All vehicle-related projections were obtained from EPA's MOBILE3 fuel consumption model.

Table 2-20. COMPARISON OF ONBOARD VAPOR CONTROL HARDWARE COSTS[a] (Included Excess Evap Control)

Component or Assembly	July 1984 Analysis (1983 dollars)		New Analysis (1984 dollars)		
	LDV[b]	LDT[c]	LDV[b]	LDT[c]	HDGV[d]
Charcoal Canister	$5.07	$9.94	$ 5.74	$ 7.43	$12.79
Purge Control Valve	0.94	0.94	-	-	-
Liquid/Vapor Separator	0.91	0.91	0.92	0.92	1.10
Fillpipe Seal	1.42	1.42	-	-	0.44
"J-Tube" Assembly	-	-	1.52	1.52	1.82
Pressure Relief Valve	0.56	0.56	-	-	0.92
Rollover/Vent Valve	-	-	5.80	5.80	6.94
Hoses/Tubing	2.41	2.41	1.96	1.96	4.10
Miscellaneous Hardware	0.51	0.51	1.03	1.03	1.24
Vehicle Assembly	1.00	1.00	0.11	0.11	0.14
Systems Engineering/ Certification	0.50	0.50	1.20	1.68	3.73
Modification/Packaging	-	-	1.72	1.75	1.58
Total (1990-1994)[e]	$13.32	$18.19	$20.00	$22.20	$34.30

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[a] Retail Price Equivalents on all costs.

[b] LDV = Light-duty vehicles.

[c] LDT = Light-duty trucks (with single tanks).

[d] HDGV = Heavy-duty gasoline vehicles (weighted averages for Classes IIb and VI single- and dual-tank trucks).

[e] Other total onboard costs in the new analysis are:

	LDV	LDT	HDGV
1995-1999:	$17.70	$19.60	$29.80
2000 on:	$16.30	$18.10	$29.40

Table 2-21. NEW VEHICLE REGISTRATION PROJECTIONS

NEW VEHICLES (Millions)

	July 1984 Analysis	New Analysis			
Year	(Total Vehicles)	Total	LDV	LDT	HDGV
1988	13.35	0	0	0	0
1989	13.30	0	0	0	0
1990	13.13	15.29	11.2	3.71	0.384
1991	13.48	15.26	11.2	3.68	0.381
1992	13.68	15.22	11.2	3.64	0.379
1993	13.60	15.04	11.1	3.56	0.381
1994	13.76	14.85	11.0	3.47	0.383
1995	13.76	14.53	10.8	3.35	0.384
1996	13.76	14.69	10.9	3.40	0.385
1997	13.76	14.82	11.0	3.43	0.388
1998	13.76	14.84	11.0	3.45	0.392
1999	13.76	14.86	11.0	3.46	0.396
2000	13.76	14.88	11.0	3.48	0.400
2001	13.76	[illegible]	11.0	3.48	0.400
2002	13.76	14.88	11.0	3.48	0.400
2003	13.76	14.88	11.0	3.48	0.400
2004	13.76	14.88	11.0	3.48	0.400
2005	13.76	14.88	11.0	3.48	0.400
2006	13.76	14.88	11.0	3.48	0.400
2007	13.76	14.88	11.0	3.48	0.400
2008	13.76	14.88	11.0	3.48	0.400
2009	13.76	14.88	11.0	3.48	0.400
2010	13.76	14.88	11.0	3.48	0.400
2011	13.76	14.88	11.0	3.48	0.400
2012	13.76	14.88	11.0	3.48	0.400
2013	13.76	14.88	11.0	3.48	0.400
2014	13.76	14.88	11.0	3.48	0.400
2015	13.76	14.88	11.0	3.48	0.400
2016	13.76	14.88	11.0	3.48	0.400
2017	13.76	14.88	11.0	3.48	0.400
2018	13.76	14.88	11.0	3.48	0.400
2019	13.76	14.88	11.0	3.48	0.400
2020	13.76	14.88	11.0	3.48	0.400

The analysis also incorporates recovery credits for the onboard system. In the July 1984 analysis, it was assumed that the added weight of the onboard system would offset any potential recovery credits. Since the amount available for recovery (higher emissions due to increased RVP) increased, the new analysis considers the net fuel savings, taking into account the weight penalty of the onboard system, obtained over the life of the vehicle. Table 2-22 contains the refueling recovery credit factors used in the onboard cost analysis.

2.5.2.5 Costs of Excess Evaporative Controls. For purposes of evaluating the excess evaporative strategy, the cost, emissions, and risk impacts were analyzed. Table 2-23 summarizes the per-vehicle costs, emission factors, and recovery credits associated with excess evaporative controls. Since the emission factors consist of only the "excess" evaporative emissions not being collected by the current canister system, a properly designed evaporative canister would eliminate all "excess" emissions. Therefore, it is assumed that the strategy will provide 100 percent control of the excess evaporative emissions. Projections for the nationwide impacts of this strategy are based on the same vehicle miles traveled and vehicle registration data used in the onboard projections.

The costs presented in Table 2-23 decrease in 1994 because the initial engineering costs are assumed to be recouped in the first 5 years (1990-1994). Unlike onboard, excess evaporative control costs are constant after 1995 since future increased fuel economy and the resultant smaller fuel tank do not affect excess evaporative emissions and, therefore, excess evaporative hardware.

2.5.3 Control Options

Nationwide cost impacts for the regulatory strategies were calculated in a manner similar to that used in the July 1984 analysis. For non-service station sectors, per-facility costs were multiplied by the number of controlled facilities (see Table 2-9) to establish a cost in the base year. Costs then varied with time based on recovery credits changing proportional to the changes in gasoline consumption. Several new concepts were added to the nationwide analysis of service station costs. The greatest impacts resulted from the inclusion of service station facility projections in each year (see Section 2.3.2). In the

Table 2-22. REFUELING RECOVERY CREDITS USED IN THE ONBOARD ANALYSIS

Vehicle Type	Recovery Credits (10^{-5} gallon/mile)[a]			
	1990	1995	2000	2010
LDV[b]	6.6	6.0	5.5	5.0
LDT[c]	8.6	8.3	7.6	6.9
LDT(2)[d]	4.4	4.2	3.9	3.6
HDGV[e]	21	20	19	18

[a] Applies to well-maintained (nontampered with) onboard systems.

[b] LDV = Light-duty vehicle.

[c] LDT = Light-duty truck.

[d] LDT(2) = Light-duty trucks with dual fuel tanks.

[e] HDGV = Heavy-duty gasoline vehicle.

Table 2-23. SUMMARY OF EXCESS EVAPORATIVE CONTROL STRATEGY COSTS AND RECOVERY CREDITS

Excess Evaporative Emission Recovery Credits (10^{-5} gal/mile)

LDV[b]	6.3
LDT[c]	9.1
HDGV[d]	15

Per-Vehicle Cost for Excess Evaporative Emission Controls ($)

	1990	1995	2000
LDV[b]	2.90	2.00	2.00
LDT[c]	3.80	2.60	2.60
HDGV[d]	4.20	3.50	3.50

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[a] That portion of the excess evaporative emissions that can be controlled by enlarging the existing carbon canister or by using a combined refueling and evap canister.

[b] LDV = Light-duty vehicle.

[c] LDT = Light-duty truck.

[d] HDGV = Heavy-duty gasoline vehicle.

[e] Weighted by VMT for the year 2010.

new analysis, projected declines in gasoline consumption yield fewer public facilities over time rather than a constant number of smaller public facilities. (The number of private facilities is still assumed to be constant.) The projection method and the detailed per-facility costs allowed for the cost distinction to be made between Stage II installations at new facilities and at retrofit facilities. The projection method kept track of new and existing facilities separately, and the detailed per-facility cost model enabled the distinction to be made in piping and trenching costs between new construction and retrofit installations. The detailed per-facility cost model also separated the aboveground, or dispenser, equipment from the underground piping. This allowed the calculation of annualized costs using a capital recovery factor based on the different expected lives of the underground and aboveground equipment (35 years and 8 years, respectively).

Other modifications to the cost analysis, similar to emissions and risk, were as follows:

- onboard per-vehicle costs were increased; however, this was offset by the inclusion of recovery credits (Section 2.5.2);
- excess evaporative control costs, including recovery credits, were added in considering these controls as a separate strategy (Section 2.3.3);
- onboard and evaporative controls were considered for only 49 States (California excluded because Stage II and RVP controls already implemented) (Section 2.3.3);
- Stage II controls would be required for the rest of the State of California under the 49-State onboard strategy (Section 2.3.3);
- heavy-duty vehicle controls were included for both the onboard and excess evaporative regulatory strategies (Section 2.3.3);
- net present value streams were adjusted to reflect the new start dates for the regulatory strategies (Section 2.3.3);
- bulk terminal carbon adsorber costs were adjusted to respond to comments (Section 2.5.2); and
- recovery credits for all facilities were adjusted to reflect new emission factors, updated gasoline costs, and revised gasoline consumption projections (Section 2.5.1).

Table 2-24 summarizes the revised annual costs for the control options and Table 2-25 summarizes the annual costs for the regulatory strategies. As with the emission tables, the ranges shown for Stage II nationwide costs are from minimal enforcement (7-year phase-in) to annual enforcement (3-year phase-in). For Stage II in nonattainment areas the range is from minimal enforcement, high-difficulty phase-in to annual enforcement, low-difficulty phase-in. Enforcement costs, discussed in Section 2.8, are included in these cost estimates.

Stage II non-installations associated with minimal enforcement were handled differently in the new analysis. In the July 1984 analysis, all non-installations were considered equivalent to no equipment installed, and the facilities were completely excluded from the cost analysis. In evaluating the new in-use data it was determined that most of the non-installations (10 of the 14 percent) were at stations with at least some equipment installed. For these cases it was assumed the facility had installed all underground piping, and had simply not installed all the aboveground equipment. The cost of the aboveground equipment not installed was excluded from the analysis. For the other 4 percent of the non-installations, it was assumed that no vapor recovery equipment, above- or belowground, had been installed. These facilities were, therefore, completely excluded from the cost analysis. Appendix D discusses in-use efficiencies and non-installations in greater detail.

2.6 RISK ANALYSIS

The general methodology employed in the July 1984 analysis for assessing risk was not changed. Several adjustments were made, however, for the sake of consistency and to correct errors. In the list of adjustments shown below, the first two affect only the baseline risk estimates while all of the adjustments affect the projected risk reductions due to the regulatory strategies. Adjustments include the:

- o incorporation of revised gasoline consumption and VMT projections (Section 2.3.2);
- o reassessment of the original baseline control levels based on new input data (Section 2.4.1);
- o incorporation of new emission factors (Section 2.1);

Table 2-24. NATIONWIDE COSTS OF GASOLINE MARKETING OPTIONS (1988-2020)

Facility Type (with Size Exemptions and In-Use Efficiencies)	Annualized Costs (Millions of Third Quarter 1984 Dollars)		
	Average Annual[a]	Annualized[b]	2010[c]
STAGE I			
Bulk Terminals			
- Loading Racks	25	30	18
- Storage Tanks	(7)[f]	(6)	(7)
Bulk Plants	9	9	10
For-Hire Tank Trucks			
- Terminal Trucks	10	9	11
- Bulk Plant Trucks	17	15	18
Service Stations (Stage I)			
- Nationwide	16	15	18
VEHICLE REFUELING			
Service Stations[d]			
- Nationwide	190-200	170-190	210
- 61 Areas	69-84	58-92	79
- 27 Areas	45-55	38-60	52
- 11 Areas	30-36	25-39	34
Onboard[e]	180	150	200
EXCESS EVAPORATIVE	(46)	(28)	(66)

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[a] Average Annual = cumulative divided by 33.

[b] Annualized = 1988 Net Present Value of costs reannualized over 1988-2020 to a stream of constant values.

[c] Costs estimated in the year 2010.

[d] Range of values represents the range of efficiencies found between a Stage II program of minimal enforcement and an active (annual) enforcement program. For nationwide strategies, the range is minimal enforcement (7-yr phase-in) to annual enforcement (3-yr phase-in). For nonattainment area strategies, the range is from minimal enforcement (high-difficulty phase-in) to annual enforcement (low-difficulty phase-in). If no range is indicated, the upper and lower values vary by less than 10 percent and the average is presented.

[e] Includes excess evaporative cost benefits.

[f] Parentheses indicate negative costs, or a net cost savings.

Table 2-25. NATIONWIDE COSTS OF GASOLINE MARKETING REGULATORY STRATEGIES (1988-2020)

Regulatory Strategy (with Size Exemptions and In-Use Efficiencies)	Annualized Costs (Millions of Third Quarter 1984 Dollars)		
	Average Annual[a]	Annualized[b]	2010[c]
Stage I - Nationwide	73	74	68
Evaporative Controls	(46)[g]	(28)	(66)
Stage II - 27 Areas[d]	45-55	38-60	52
Stage II - 27 Areas,[d] Plus Evaporative Controls	(1)-9	10-32	(14)
Stage II - Nationwide[d]	190-200	170-190	210
Stage II - Nationwide,[d] Plus Evaporative Controls	140-150	140-160	140
Onboard Nationwide[e]	180	150	200
Stage II - 27 Areas,[d] Plus Onboard Nationwide[e]	210	180-200	220

[a] Average Annual = cumulative divided by 33.

[b] Annualized = 1988 Net Present Value of costs reannualized over 1988-2020 to a stream of constant values.

[c] Costs estimated in the year 2010.

[d] Range of values represents the range of efficiencies found between a Stage II program of minimal enforcement and an active (annual) enforcement program. For nationwide strategies, the range is minimal enforcement (7-yr phase-in) to annual enforcement (3-yr phase-in). For nonattainment area strategies, the range is from minimal enforcement (high-difficulty phase-in) to annual enforcement (low-difficulty phase-in). If no range is indicated, the upper and lower values vary by less than 10 percent and the average is presented.

[e] Includes excess evaporative cost benefits.

[f] Parentheses indicate negative costs, or a net cost savings.

- revision of start dates for the regulatory strategies (Section 2.3.3);
- incorporation of the 49-State onboard and excess evaporative strategies (Section 2.3.3);
- addition of the 7-year phase-in for minimal enforcement nationwide Stage II strategies (Section 2.3.3);
- incorporation of revised nonattainment area groupings (Section 2.3.3);
- addition of heavy-duty vehicle control impacts to the onboard and evaporative strategies (Section 2.3.3); and
- change from a 16-year to an 8-year implementation of Stage II when in combination with onboard (Section 2.3.3).

2.6.1 Risk Factors

Several comments were received concerning the benzene and gasoline vapor risk factors. One commenter brought to the Agency's attention new information on benzene exposure from a California study (I-F-103). This new information on benzene was evaluated along with the previous available information by EPA's Carcinogen Assessment Group (CAG). The CAG also re-evaluated the API data used to develop the gasoline vapor risk factors as a result of comments from the Science Advisory Board (SAB), in which a correction to the API data was provided. On the basis of the re-evaluation of the benzene studies, including the new California study, CAG provided a new benzene risk factor that is about 17 percent higher than the one used in the original analysis. The CAG's re-evaluation of the API data resulted in a decrease of about 11 percent in the gasoline vapor risk factors. Table 2-26 summarizes the revised risk factors used in the new analysis.

2.6.2 Occupational Exposure

A significant addition to the risk analysis was the inclusion of the evaluation of occupational exposure reductions associated with the vehicle refueling strategies. Both Stage II and onboard controls would reduce not only community and self-service exposures, but also exposures to the service station attendants. The base year occupational incidence and lifetime risk from high exposure were calculated for benzene and gasoline vapors based on time-weighted average concentrations reported in an industrial hygiene study conducted by Shell Oil (I-F-141). Several

Table 2-26. COMPARISON OF BENZENE AND GASOLINE VAPOR UNIT RISK FACTORS

Pollutant	Risk Factors[a] July 1984 Analysis[b]	New Analysis
Benzene	2.2×10^{-2}	2.6×10^{-2}
Gasoline Vapors		
- Rat Studies		
o PUL[c]	3.5×10^{-3}	3.1×10^{-3}[e]
o MLE[d]	2.0×10^{-3}	2.0×10^{-3}
- Mice Studies		
o PUL[c]	2.1×10^{-3}	2.1×10^{-3}
o MLE[d]	1.4×10^{-3}	1.4×10^{-3}

[a] Probability of a cancer incidence for 1 ppm over a 70-year lifetime.

[b] Original EPA analysis published in July 1984 (EPA-450/3-84-012a).

[c] PUL = Plausible Upper Limit.

[d] MLE = Maximum Likelihood Estimate.

[e] Risk factor used as basis for gasoline vapor risk estimates in revised analysis.

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assumptions had to be made to project occupational incidences into the future, because little data were available. The assumptions for projecting occupational exposures included:

- o assuming the changes in baseline occupational incidence with time are proportional to the changes in total service station gasoline throughput;
- o assuming that reductions in occupational incidence would be equal to 75 percent of the combined reduction achieved under each strategy for service station and self-service incidence (i.e., some occupational exposures from garage or cleaning activities will not be reduced by vehicle refueling controls); and
- o assuming service station Stage I controls have no effect on occupational incidence.

Appendix H contains a detailed discussion of the methodology used to estimate incidence associated with occupational exposure.

2.6.3 Baseline Risks

Table 2-27 contains the baseline average annual incidence and lifetime risk from high exposure calculated under the new analysis. Ranges of values, used in the July 1984 analysis, have been eliminated to simplify the data presentation and calculations. The gasoline vapor risk values are based on the plausible upper limit of the API rat studies. Table 2-28 presents the incidence reductions for the regulatory strategies calculated in the new analysis. Values in Table 2-28 represent the sum of the benzene and gasoline vapor incidence reductions. Since the benzene and gasoline vapor studies indicate that tumor sites occur in separate body systems (kidney or liver cancer for gasoline vapors, leukemia for benzene), it is assumed that reduction of refueling emissions would reduce risk by the sum of the benzene and gasoline vapor incidence reductions. Figure 2-7 illustrates the incidence reduction that occurs with time for the onboard and Stage II strategies.

2.6.4 Hazardous Fraction of Gasoline Vapors

Several commenters stated that the incidence due to gasoline vapors is due only to the fraction of the vapors containing primarily branched chain aliphatic hydrocarbons having 6-9 carbon atoms. A

Table 2-27. SUMMARY OF BASELINE RISKS[a]

Facility Category	Lifetime Risk From High Exposure	Average Annual Incidence	
		Benzene	Gasoline Vapors
Bulk Terminals	5.7×10^{-3}	0.1	3.5
Bulk Plants	2×10^{-4}	0.05	1.4
Service Stations			
o Community Exposure			
- Stage I	6.7×10^{-5}	0.1	3
- Stage II	1×10^{-4}	0.4	10
(Total)	(1.6×10^{-4})	(0.5)	(13)
o Self-Service	8×10^{-5}	4.4	33
Total Public Incidence		5.1	51
Occupational (Service Stations)	4×10^{-3}	1.7[b]	17[b]
Total Incidence for Gasoline Marketing Source Category		6.8	68
Controllable Excess Evap Emissions		0.4	6

[a] Baseline risks are those projected throughout the study period (1988-2020) with no additional controls.

[b] Values differ from those on page H-4 of Appendix H. Values in Appendix H are for the base year (1984), while values in this table are the average annual values for the study period of 1988-2020.

Table 2-28. SUMMARY OF INCIDENCE IMPACTS UNDER
REVISED ANALYSIS FOR GASOLINE MARKETING
REGULATORY STRATEGIES
(1988-2020)

Regulatory Strategy (with Size Exemptions)	Average Annual Residual Incidence (Benzene/Gas Vapors)						Reduction From Baseline[a]
	Bulk Terminals	Bulk Plants	Service Stations	Self-Service	Occupational	Total[a]	
Baseline	0.1/4	0.05/1	0.5/13	4/33	2/17	7/68	--
Stage I - Nationwide	0.09/2	0.02/0.5	0.4/11	4/33	2/17	7/64	0.1/4
Evaporative Controls	0.1/4	0.05/1	0.5/13	4/33	2/17	7/68	0.4/6[b]
Stage II - 27 Areas	0.1/4	0.05/1	0.4/11	4/29	2/15	6/58	1/10
Stage II - 27 Areas Evaporative Controls	0.1/4	0.05/1	0.4/11	4/29	2/15	6/58	1/14-16[b]
Stage II - Nationwide[c]	0.1/4	0.05/1	0.3/8-9	2-3/14-20	1/10-12	3-4/36-46	4-4/22-32
Stage II - Nationwide,[c] Evaporative Controls	0.1/4	0.05/1	0.3/8-9	2-3/14-20	1/10-12	3-4/36-46	4-4/28-38[b]
Onboard Nationwide	0.1/4	0.05/1	0.2/7	1/10	0.8/9	3/30	5/43[b]
Stage II - 27 Areas Onboard Nationwide	0.1/4	0.05/1	0.2/7	1/9	0.8/8	2/29	5/45[b]

[a] Results may not add up exactly due to rounding.

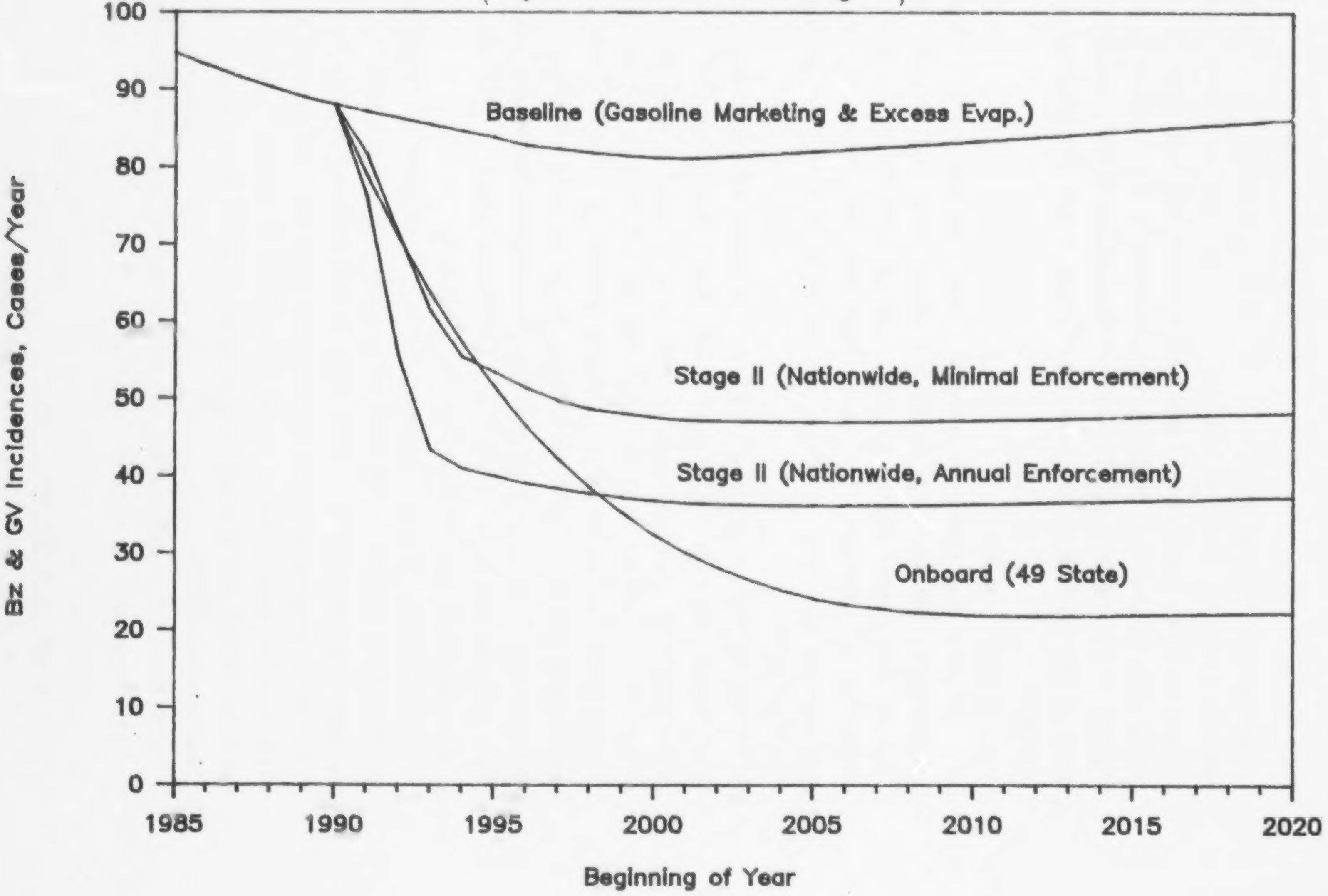
[b] Evaporative controls yield incidence reductions from vehicle operations and not from gasoline marketing.

[c] Range of values represents the range of efficiencies found between a program of minimal enforcement (62 percent) and an active (annual) enforcement program (86 percent) and the range of equipment phase-in schedules (3-7 years). If no range is indicated, the upper and lower values vary by less than 10 percent and the average is presented.

Figure 2-7.

BENZENE AND GASOLINE VAPOR INCIDENCES

(Impacts of Onboard and Stage II)



conservative estimate based on data from API (I-D-51), HEI (I-A-65), and EPA (I-A-67) indicates that the ratio of C_6-C_9 compounds in the liquid to C_6-C_9 compounds in the vapors is a factor of about 4 to 1. Using this assumption, the gasoline vapor risks would be reduced by a factor of 4. Table 2-29 illustrates the impacts these revisions would have on the average annual baseline incidence for the gasoline marketing category.

2.7 ECONOMIC IMPACTS

In order to respond to comments concerning the economic impacts of controls, the Agency re-evaluated several facility cost estimates and all costs were updated to third-quarter 1984 dollars. Also, the number of service stations in each size class was projected for each year of the analysis. Finally, two alternative exemption options were considered.

The estimated gasoline retail price increases expected from the nationwide regulatory strategies range from 0.10¢/gallon for Stage I with exemptions, to 0.62¢/gallon for Stage II with no exemptions. The national reduction in gasoline consumption predicted to result ranges from 33 million to 217 million gallons per year. Under onboard and excess evaporative control, vehicle prices would increase by about 0.2 percent. Vehicle sales could decrease by a similar percentage, or the decrease could be less if purchasers were aware of the cost savings resulting from fuel recovery by the system.

Reductions in gasoline consumption attributable to higher gasoline prices would result in the closure of some service stations. The new analysis estimates that, under Stage II nationwide, between 150 and 560 public service stations would close (0.09 to 0.33 percent of the 1990 station population). Under Stage II in 61 nonattainment areas, between 50 and 250 stations would close (0.03 to 0.15 percent of the 1990 population).

Appendix E discusses the methodologies and more detailed results of the reanalysis of economic impacts.

2.8 ENFORCEMENT COST IMPACTS

2.8.1 Stage II Enforcement Costs

In the July 1984 analysis, calculations were presented for minimal, bi-annual, annual, and quarterly enforcement scenarios. In

Table 2-29. COMPARISON OF BASELINE HIGH AND LOW INCIDENCE ESTIMATES

Risk Factor Estimate Using:	Total Average Annual Incidence for the Gasoline Marketing Source Category		
	Benzene	Gasoline Vapors	Bz + GV
EPA Analysis	6.8	68	75
C_6 and Higher[a] Gasoline Vapors Only	6.8	17	24

[a] For purposes of this analysis, an average factor of 4.0 to 1 was used for the ratio of $\geq C_6$ (Liquid) to $\geq C_6$ (Vapor)

the revised analysis, calculations were performed only for minimal and annual enforcement. Minimal enforcement represented the low end of the range of actual enforcement practice, while annual enforcement represented the high end of the range of actual enforcement. These enforcement levels define the range for the calculation of Stage II impacts.

The calculation methodology used in the new analysis is identical to that used in the July 1984 analysis. Enforcement is determined on a per-facility basis and then multiplied by the number of affected facilities. However, three changes have been incorporated into the new analysis. First, since the number of service stations changes with time and since the enforcement costs are based on the number of facilities, the enforcement costs associated with Stage II change with time. Second, the average salary figure for a field inspector was increased to respond to comments. The yearly wage was adjusted from the 1982 base year value of $30,000 per year to the 1984 base year value of $38,200 per year. Third, enforcement impacts were considered negligible for the onboard and evaporative control scenarios. It was assumed that these programs could be absorbed into the existing vehicle certification program at no additional cost. However, enforcement costs were associated with the 49-State onboard scenario to account for the additional enforcement of Stage II controls required in the current uncontrolled areas of California. All other inspection times, frequencies, and legal and clerical assumptions remained the same as in the July 1984 analysis. Table 2-30 summarizes the enforcement costs associated with the regulatory strategies under the new analysis.

2.8.2 Onboard Enforcement Costs

In the July 1984 analysis, enforcement costs were estimated at an additional $150,000/year. This cost was based on the inclusion of onboard system inspections in the existing vehicle certification programs. In the new analysis, it was assumed that the onboard inspections would be incorporated into the existing vehicle certification program at no additional cost. The only enforcement costs associated with the new onboard strategy are the costs of enforcing requirements for the new Stage II systems that would be required in the areas of California that are currently uncontrolled.

Table 2-30. SUMMARY OF ANNUAL ENFORCEMENT IMPACTS ASSOCIATED WITH THE REGULATORY STRATEGIES (1988-2020)

Regulatory Strategy (with Size Exemptions)	Enforcement Resources (Person-Years)		Costs (Millions of 1984 Dollars)		
	Cumulative	Average Annual	Average Annual[a]	Annualized[b]	2010[c]
Stage I - Nationwide	1,800	56	2	2	2
Evaporative Controls	0	0	0	0	0
Stage II - 27 Areas[e]	1,600	50	2	2	2
Stage II - 27 Areas,[e] Plus Evaporative Controls	1,600	50	2	2	2
Stage II - Nationwide[e]	6,400	190	7	7	8
Stage II - Nationwide,[e] Evaporative Controls	6,400	190	7	7	8
Onboard[d]	80	2	0.1	0.1	0.1
Stage II - 27 Areas,[e] Plus Onboard	460	14	0.5	1	0.1

[a] Average Annual = cumulative divided by 33.

[b] Annualized = 1988 Net Present Value of costs reannualized over 1988-2020 to a stream of constant values.

[c] Costs estimated in the year 2010.

[d] Reflects enforcement costs associated with Stage II requirements in California under a 49-State onboard strategy. Enforcement costs for onboard systems can be included in existing inspection programs; therefore, the enforcement costs under this study are negligible.

[e] Reflects exemption level of <10,000 gal/mo. for all facilities and <50,000 gal/mo. for independents.

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3.0 SUMMARY OF THE ANALYSIS

The impacts of the changes made to the analysis, which are summarized in Chapter 2, are presented in this chapter. Results are presented for the regulatory strategies calculated under the new analysis (Section 3.1); the cost effectiveness for cancer cases avoided (Section 3.2); the incremental cost effectiveness for increasingly stringent levels of control and for various baselines (Section 3.3); impacts given certain assumptions concerning other benefits and other exemption levels (Section 3.4); a comparison of impacts of several control strategies in selected areas (Section 3.5); and sensitivity analyses on costs, RVP of dispensed gasoline, and regulatory coverage for onboard (Section 3.6).

3.1 REGULATORY STRATEGIES

Tables 3-1 and 3-2 summarize the impacts of the regulatory strategies calculated under the new analysis. Table 3-1 presents the impacts as analyzed over the entire 33-year analysis period (1988-2020). Values for emission and risk reductions are shown for both the average annual values (33-year cumulative total divided by 33) and the annualized values (1988 net present value of all years to 2020 reannualized to represent a constant stream of values). Cost effectiveness is shown as both net present value dollars per net present value megagram of VOC reduced, and as net present value dollars per net present value cancer case avoided. The dollars per case avoided does not consider any other benefit value for reducing VOC emissions. Table 3-2 contains values similar to those in Table 3-1, except that the values in Table 3-2 represent the impacts of the regulatory strategies in the future after full implementation of the strategies is complete (the year 2010 was selected to represent this steady state condition).

3.2 COST EFFECTIVENESS

Tables 3-3, 3-4, and 3-5 further evaluate the cost per cancer case avoided analysis. These three tables, indicating benzene only impacts, benzene plus EPA estimate of gasoline vapor impacts, and benzene plus C_6 and greater gasoline vapor impacts, respectively, analyze the cost per cancer case avoided assuming that various dollar values are assigned as additional benefits for reducing VOC emissions.

Table 3-1. SUMMARY OF IMPACTS OF REGULATORY STRATEGIES (33-YEAR ANALYSIS)[a]

Regulatory Strategy	Incidence Reduction (Bz + GV)[b]		VOC Emission Reduction, 10^3 Mg/yr		Annualized Costs, Including Enforcement ($\$10^6$)	Cost Effectiveness	
	Average Annual	Annualized	Average Annual	Annualized		\$/Mg VOC Removed[c]	\$ Million/Case Avoided[d]
Baseline	[84]	[93]					
Stage I - Nationwide	3.8	3.3	310	280	74	260	22
Evaporative Controls[e]	6.4	4.4	250	180	(28)[f]	(160)[f]	(0)[f]
Stage II-27 Areas	7 - 11	6 - 12	43 - 67	35 - 70	38 - 60	850 - 1,080	5 - 7
Stage II-27 Areas, plus Evaporative Controls[e]	14 - 18	10 - 16	290 - 320	210 - 250	10 - 32	50 - 130	1 - 2
Stage II - Nationwide	25 - 35	21 - 32	180 - 260	160 - 230	170 - 190	810 - 1,060	6 - 8
Stage II - Nationwide, Plus Evaporative Controls[e]	31 - 42	26 - 36	430 - 510	330 - 410	140 - 160	400 - 420	4 - 5
Onboard Nationwide[e]	48	35	530	380	150	380	4
Stage II-27 Areas, plus Onboard Nationwide[e]	49	36 - 39	540	400	190	460 - 480	5

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[a] Ranges of values represent the range of efficiencies found between a Stage II program of minimal enforcement and an active (annual) enforcement program. For nationwide strategies, the range is from minimal enforcement (7-year phase-in), to annual enforcement (3-year phase-in). For nonattainment area strategies, the range is from minimal enforcement, high-difficulty phase-in to annual enforcement, low-difficulty phase-in. If no range is indicated, the upper and lower values vary by less than 10 percent and the average is presented.

[b] GV = gasoline vapors (plausible upper limit rat data only). Benzene incidence alone would be about 10 percent of the total incidence reduction. Includes incidence reduction from service station attendant occupational exposure.

[c] Cost effectiveness per emission reduction is the net present value of costs divided by the net present value of emissions, both discounted at 10 percent.

[d] Cost effectiveness per incidence reduction is the net present value of costs divided by the net present value of incidence reduction, both discounted at 10 percent, with no VOC benefits.

[e] Includes expected level of tampering and impacts associated with the reduction in excess evaporative emissions.

[f] Cost savings.

Table 3-2. SUMMARY OF IMPACTS OF REGULATORY STRATEGIES (AFTER FULL IMPLEMENTATION IN YEAR 2010)[a]

Regulatory Strategy	Incidence Reduction (Bz + GV)[b]	VOC Emission Reduction, 10^3 Mg/yr	Annual Cost, Including Enforcement, ($\$10^6$)	Cost Effectiveness	
				\$/Mg VOC Removed[c]	\$ Million/Case Avoided[d]
Baseline	[83]				
Stage I - Nationwide	4	340	68	210	17
Evaporative Controls	9	330	(66)[e]	(200)	(0)
Stage II-27 Areas	8 - 11	50 - 69	52	770 - 1,030	5 - 6
Stage II-27 Areas, plus Evaporative Controls	17 - 20	300 - 390	(14)	(32) - (40)	(0)
Stage II - Nationwide	28 - 39	200 - 280	210	750 - 990	6 - 7
Stage II - Nationwide, plus Evaporative Controls	36 - 47	530 - 610	140	240 - 260	3 - 4
Onboard Nationwide[f]	62	680	200	290	3
Stage II-27 Areas, plus Onboard Nationwide[f]	62	680	220	320	4

[a] Ranges of values represent the range of efficiencies found between a Stage II program of minimal enforcement and an active (annual) enforcement program. For nationwide strategies, the range is from minimal enforcement (7-year phase-in), to annual enforcement (3-year phase-in). For nonattainment area strategies, the range is from minimal enforcement, high-difficulty phase-in to annual enforcement, low-difficulty phase-in. If no range is indicated, the upper and lower values vary by less than 10 percent and the average is presented.

[b] GV = gasoline vapors (plausible upper limit rat data). Benzene incidence alone would be about 4 percent of the total for Stage I and about 10 percent of the total for other options. Includes incidence reduction from service station attendant occupational exposure.

[c] Cost effectiveness per emission reduction is annual cost divided by emission reduction.

[d] Cost effectiveness per incidence reduction is annual cost divided by incidence reduction.

[e] Parentheses indicate negative cost, or net cost savings.

[f] Includes expected level of tampering and impacts associated with the reduction in excess evaporative emissions.

Table 3-3. BENZENE REGULATORY COSTS PER CANCER INCIDENCE AVOIDED (33-YEAR ANALYSIS)

Regulatory Strategy (with size cutoffs[a]) (in-use efficiency; Phase-in Schedule)	Annualized Cost, Including Enforcement ($ Millions)	Average Annual Benzene Incidence Reduction	Cost ($ Millions per Bz Cancer Incidence Avoided), Assuming a Nationwide VOC Benefit Value of:			
			$0/Mg	$250/Mg	$500/Mg	$1,000/Mg
Stage I (All Sectors)	74	0.12				
- Bulk Terminals	34	0.04	680	27	(0)[b]	(0)
- Bulk Plants	24	0.03	1,080	320	(0)	(0)
- Service Stations	16	0.06	920	200	(0)	(0)
			310	(0)	(0)	(0)
Evaporative Controls	(28)[b]	0.44	(0)	(0)	(0)	(0)
Stage II-27 Areas						
- (Annual, Lo Diff.)	60	1.0	57	40	24	(0)
- (Minimal, Hi Diff.)	38	0.6	72	56	39	5
Stage II-27 Areas Plus Evaporative Controls						
- (Annual, Lo Diff.)	32	1.5	24	(0)	(0)	(0)
(Minimal, Hi Diff.)	10	1.1	12	(0)	(0)	(0)
Stage II - Nationwide						
- (Annual)	190	2.5	60	41	23	(0)
- (Minimal)	170	2.5	78	60	41	5
Stage II - Nationwide Plus Evaporative Controls						
- (Annual)	160	4.0	46	17	(0)	(0)
- (Minimal)	140	2.9	57	22	(0)	(0)
Onboard Nationwide (95%)	150	4.6	44	15	(0)	(0)
Stage II-27 Areas Plus Onboard Nationwide						
- (Annual, Lo Diff.)	200	4.8	52	25	(0)	(0)
- (Minimal, Hi Diff.)	180	4.7	51	23	(0)	(0)

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[a] Size cutoffs for Stage II - Nationwide and for Stage II-27 Areas, exempt all facilities smaller than 10,000 gal/mo and independent facilities smaller than 50,000 gal/mo.

[b] Numbers in parentheses denote net cost savings.

Table 3-4. BENZENE AND GASOLINE VAPORS COSTS PER CANCER INCIDENCE AVOIDED (33-YEAR ANALYSIS)

Regulatory Strategy (with size cutoffs[a]) (In-use efficien[illegible] Phase-in Schedu[illegible])	Annualized Costs, Including Enforcement ($ Millions)	Average Annual Incidence Reduction (Bz+GV)[b]	Cost ($ Millions per Bz + GV Cancer Incidence Avoided), Assuming a Nationwide VOC Benefit Value of:			
			$0/Mg	$250/Mg	$500/Mg	$1,000/Mg
Stage I (All Sectors)	74	3.8	22	0.9	(0)[c]	(0)
- Bulk Terminals	34	1.0	37	11	(0)	(0)
- Bulk Plants	24	0.9	31	7	(0)	(0)
- Service Stations	16	1.8	10	(0)	(0)	(0)
Evaporative Controls	(28)[c]	6.4	(0)	(0)	(0)	(0)
Stage II-27 Areas						
- (Annual, Lo Diff.)	60	11	5	4	2	(0)
- (Minimal, Hi Diff.)	38	7	7	5	4	0.5
Stage II-27 Areas Plus Evaporative Controls						
- (Annual, Lo Diff.)	32	18	2	(0)	(0)	(0)
- (Minimal, Hi Diff.)	10	14	1	(0)	(0)	(0)
Stage II - Nationwide						
- (Annual)	190	35	6	4	2	(0)
- (Minimal)	170	25	8	6	4	0.5
Stage II - Nationwide Plus Evaporative Controls						
- (Annual)	160	42	4	2	(0)	(0)
- (Minimal)	140	31	5	2	(0)	(0)
Onboard Nationwide,	150	48	4	2	(0)	(0)
Stage II-27 Areas Plus Onboard Nationwide						
- (Annual, Lo Diff.)	200	50	5	2	(0)	(0)
- (Minimal, Hi Diff.)	180	49	5	2	(0)	(0)

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[a] Size cutoffs for Stage II - Nationwide and for Stage II-27 Areas exempt all facilities smaller than 10,000 gal/mo and independent service stations smaller than 50,000 gal/mo.

[b] GV = gasoline vapors (plausible upper limit rat data only).

[c] Numbers in parentheses denote net cost savings.

Table 3-5. BENZENE AND GASOLINE VAPORS COSTS PER CANCER INCIDENCE AVOIDED (33-YEAR ANALYSIS) (ASSUMING INCIDENCE FROM C_6 AND GREATER GASOLINE VAPORS)

Regulatory Strategy (with size cutoffs[a]) (In-use efficiency; Phase-in Schedule)	Annualized Costs, Including Enforcement ($ Millions)	Average Annual Incidence Reduction (Bz+GV)[b]	Cost ($Millions per Bz + GV Cancer Incidence Avoided), Assuming a Nationwide VOC Benefit Value of:			
			$0/Mg	$250/Mg	$500/Mg	$1,000/Mg
Stage I (All Sectors)	74	1.0	81	3	(0)[c]	(0)
- Bulk Terminals	34	0.3	130	39	(0)	(0)
- Bulk Plants	24	0.2	110	24	(0)	(0)
- Service Stations	16	0.5	36	(0)	(0)	(0)
Evaporative Controls	(28)[c]	1.9	(0)	(0)	(0)	(0)
Stage II-27 Areas						
- (Annual, Lo Diff.)	60	3.5	16	12	7	(0)
- (Minimal, Hi Diff.)	38	2.2	21	16	11	2
Stage II-27 Areas Plus Evaporative Controls						
- (Annual, Lo Diff.)	32	5.5	6	(0)	(0)	(0)
- (Minimal, Hi Diff.)	10	4.2	3	(0)	(0)	(0)
Stage II - Nationwide						
- (Annual)	190	12	18	13	7	(0)
- (Minimal)	170	8.0	24	18	13	1
Stage II - Nationwide Plus Evaporative Controls						
- (Annual)	160	13	14	5	(0)	(0)
- (Minimal)	140	10	17	7	(0)	(0)
Onboard Nationwide	150	16	13	4	(0)	(0)
Stage II-27 Areas Plus Onboard Nationwide						
- (Annual, Lo Diff.)	200	16	15	7	(0)	(0)
- (Minimal, Hi Diff.)	180	16	15	7	(0)	(0)

[a] Size cutoffs for Stage II - Nationwide and for Stage II-27 Areas exempt all facilities smaller than 10,000 gal/mo and independent service stations smaller than 50,000 gal/mo.

[b] GV = C_6 and greater gasoline vapors (plausible upper limit rat data only).

[c] Numbers in parentheses denote net cost savings.

Zeros in parentheses indicate that in those cases the benefits outweigh the costs.

Table 3-6 summarizes the impacts associated with nationwide Stage I controls. Values are shown for each segment of the industry that is included in the Stage I regulatory strategy.

3.3 INCREMENTAL ANALYSIS

An incremental cost effectiveness analysis was performed to determine the cost effectiveness (both in \$/Mg of VOC reduced and in \$/incidence avoided) of moving from one level of control to the next level. This serves as input to determine whether it is prudent to go the "extra step" in controlling emissions or incidence. Two analyses are presented. In the first, regulatory strategies are evaluated incremental to each other. In the second, regulatory strategies are compared incremental to different baselines.

Tables 3-7 and 3-8 present the analysis of strategies incremental to each other. The analysis starts with the assumption that a decision had been made to implement evaporative controls, since this strategy was the most cost effective. Then the costs to go the "extra step" to the next strategy, Stage II in 27 nonattainment areas plus evaporative controls, are calculated. Finally, given the assumption that it was prudent to go the extra step to Stage II in 27 areas plus evaporative controls, the costs to go the next step to either Stage II-nationwide plus evaporative or onboard are calculated. Table 3-7 presents the incremental cost effectiveness on a \$/Mg of VOC reduced basis and Table 3-8 presents the incremental cost effectiveness on a \$/incidence avoided basis.

Tables 3-9 and 3-10 present the analysis of strategies incremental to different baselines. For Table 3-9, it was assumed that a decision to implement evaporative controls had been made. Table 3-9 then illustrates the impacts of taking the "extra step" from evap to implement either Stage II in 27 areas or onboard in 49 States. For Table 3-10, it was assumed that a decision had been made to implement Stage II in 27 areas in addition to evaporative controls. Table 3-10 then illustrates the impacts of taking the "extra step" to either Stage II or onboard controls nationwide.

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Table 3-6. SUMMARY OF IMPACTS OF STAGE I CONTROLS NATIONWIDE

Source Category	Average Annual Incidence Reduction (Bz & GV)	Average Annual VOC Emission Reduction, 10^3 Mg	Annualized Costs, Including Enforcement, $ Million	Cost Effectiveness		
				$/Mg	$/Incidence @ $0/Mg VOC	$/Incidence @ $250/Mg VOC
Bulk Terminals	1.0	100	34	360	37	11
Bulk Plants	0.9	83	24	320	31	7
Service Station Underground Tanks	1.8	120	16	140	10	(0)
Total Stage I	4	310	74	260	22	0.9

Table 3-7. INCREMENTAL COST EFFECTIVENESS OF SELECTED REGULATORY STRATEGIES -- VOC EMISSION REDUCTION BASIS

Regulatory Strategy	NPV of VOC Emission Reduction (1988-2020), 10^3 Mg	NPV of Costs (1988-2020), Including Enforcement, $ Million	Cost Effectiveness[a], $/Mg	
			Average	Incremental
EVAP CONTROLS	1,680	(270)	(160)	---
STAGE II-27 AREAS, EVAP CONTROLS	2,020 - 2,350	94 - 300	50 - 130	850 - 1,080
ONBOARD NATIONWIDE	3,660	1,410	380	800 - 840[b]
STAGE II-NATIONWIDE, EVAP CONTROLS	3,170 - 3,920	1,310 - 1,550	400 - 420	790 - 1,060[c]

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[a] Cost effectiveness per emission reduction is the net present value of costs divided by the net present value of emissions, both discounted at 10 percent.

[b] Increment from Stage II-27 Areas Plus Evap. to Onboard.

[c] Increment from Stage II-27 Areas Plus Evap. to Stage II-Nationwide Plus Evap.

Table 3-8. INCREMENTAL COST EFFECTIVENESS OF SELECTED REGULATORY STRATEGIES--INCIDENCE REDUCTION BASIS

Regulatory Strategy	NPV of Incidence Reduction (1988-2020) (Bz + GV[a])	NPV of Costs (1988-2020), Including Enforcement, $ Million	Cost Effectiveness[b], $ Million/Incidence Avoided	
			Average	Incremental
EVAP CONTROLS	42	(270)	(0)	---
STAGE II-27 AREAS, EVAP CONTROLS	97 - 150	94 - 300	1 - 2	5 - 7
ONBOARD NATIONWIDE	340	1,410	4	5 - 6[c]
STAGE II-NATIONWIDE, EVAP CONTROLS	250 - 350	1,310 - 1,550	4 - 5	6 - 8[d]

[a] GV = gasoline vapors (plausible upper limit rat data only). Benzene incidence reduction alone would be about 10 percent of the total incidence reduction. Includes incidence reduction from service station attendant occupational exposure.

[b] Cost effectiveness per incidence reduction is the net present value of costs divided by the net present value of incidence reduction, both discounted at 10 percent, with no VOC benefits.

[c] Increment from Stage II-27 Areas Plus Evap. to Onboard.

[d] Increment from Stage II-27 Areas Plus Evap. to Stage II-Nationwide Plus Evap.

Table 3-9a. IMPACTS OF STAGE II IN 27 NA AREAS PLUS EXCESS EVAP CONTROLS NATIONWIDE[a] (INCREMENTAL FROM EVAP)

Pollutant Considered[b]	Annual Incidence Reduction	Annual VOC Emission Reduction, 10^3 Mg/yr	Annualized Cost, $MM/yr	$/Mg Reduced	$MM/ Incidence @ $500/Mg VOC	$MM/ Incidence @ $1,000/Mg VOC	$MM/ Incidence @ $1,500/Mg VOC
Total vapors	7 - 11	43 - 67	38 - 60	1,080 - 850	4 - 2	0.5 - (0)	(0)
$\geq C_6$ fraction	2 - 4	43 - 67	38 - 60	1,080 - 850	11 - 7	2 - (0)	(0)
Benzene only	1	43 - 67	38 - 60	1,080 - 850	39 - 24	5 - (0)	(0)

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[a] The ranges of values shown are from minimal enforcement, high-difficulty implementation phase-in to annual enforcement, low-difficulty implementation phase-in.

[b] Total vapors represents benzene plus gasoline vapors (Bz + GV), while the $\geq C_6$ fraction represents benzene plus $\geq C_6$ GV.

Table 3-9b. IMPACTS OF ONBOARD IN 49 STATES (INCREMENTAL FROM EVAP)

Pollutant Considered[a]	Annual Incidence Reduction	Annual VOC Emission Reduction, 10^3 Mg/yr	Annualized Cost, $MM/yr	$/Mg Reduced	$MM/ Incidence @ $0/Mg VOC	$MM/ Incidence @ $250/Mg VOC	$MM/ Incidence @ $500/Mg VOC
Total vapors	42	280	180	850	6	4	2
$\geq C_6$ fraction	14	280	180	850	18	12	7
Benzene only	4	280	180	850	57	40	23

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[a] Total vapors represents benzene plus gasoline vapors (Bz + GV), while the $\geq C_6$ fraction represents benzene plus $\geq C_6$ GV.

Table 3-10a. IMPACTS OF STAGE II AND EVAP CONTROLS NATIONWIDE[a] (INCREMENTAL FROM STAGE II IN 27 NA AREAS + EVAP)

Pollutant Considered[b]	Annual Incidence Reduction	Annual VOC Emission Reduction, 10^3 Mg/yr	Annualized Cost, $MM/yr	$/Mg Reduced	$MM/ Incidence @ $0/Mg VOC	$MM/ Incidence @ $250/Mg VOC	$MM/ Incidence @ $500/Mg VOC
Total vapors	18 - 24	140 - 190	130	1,060 - 790	8 - 6	6 - 4	4 - 2
$\geq C_6$ fraction	6 - 8	140 - 190	130	1,060 - 790	25 - 19	19 - 13	13 - 7
Benzene only	2 - 3	140 - 190	130	1,060 - 790	83 - 63	65 - 45	47 - 27

[a] Ranges of values represent the range of efficiencies achieved between a program of minimal enforcement and an active (annual) enforcement program. For nationwide strategies, the range is from minimal enforcement (7-year phase-in) to annual enforcement (3-year phase-in). For nonattainment area strategies, the range is from minimal enforcement, high-difficulty implementation phase-in to annual enforcement, low-difficulty implementation phase-in. If no range is shown, upper and lower values in the range differ by less than 10 percent.

[b] Total vapors represents benzene plus gasoline vapors (Bz + GV), while the $\geq C_6$ fraction represents benzene plus $\geq C_6$ GV.

Table 3-10b. IMPACTS OF ONBOARD IN 49 STATES[a] (INCREMENTAL FROM STAGE II IN 27 NA AREAS + EVAP)

Pollutant Considered[b]	Annual Incidence Reduction	Annual VOC Emission Reduction, 10^3 Mg/yr	Annualized Cost, $MM/yr	$/Mg Reduced	$MM/ Incidence @ $0/Mg VOC	$MM/ Incidence @ $250/Mg VOC	$MM/ Incidence @ $500/Mg VOC
Total vapors	35 - 30	240 - 210	140 - 120	800 - 840	6	4	2
$\geq C_6$ fraction	11 - 10	240 - 210	140 - 120	800 - 840	17 - 18	12 - 13	6 - 7
Benzene only	3 - 4	240 - 210	140 - 120	800 - 840	50 - 54	34 - 38	18 - 22

[a] The ranges of values shown represent the range of efficiencies achieved between a program of minimal enforcement (7-year phase-in) to annual enforcement (3-year phase-in).

[b] Total vapors represents benzene plus gasoline vapors (Bz + GV), while the $\geq C_6$ fraction represents benzene plus $\geq C_6$ GV.

3.4 STAGE II AND ONBOARD IMPACTS CONSIDERING OTHER BENEFITS

Table 3-11 summarizes the benefits associated with each regulatory scenario, given values for cancer incidences avoided (due to benzene and gasoline vapors) and for reduction of VOC emissions. The cost effectiveness values in this table assume that onboard costs are borne nationally, but VOC emission reductions are credited only in the designated nonattainment areas (27 or 61 areas). The calculations first show the cost effectiveness of the regulatory scenario for VOC emission reductions in various nonattainment area groupings with no additional benefits. Then the benefits associated with reducing cancer incidences due to benzene, if a cancer incidence is worth $7.5 million, are shown. Next, the benefit of reducing VOC emissions in attainment areas is added (assuming $250/Mg). Then the benefit associated with reducing incidences due to C_6 gasoline vapors is added. Finally, the benefit associated with reducing incidences from total gasoline vapors is presented. The resultant cost effectiveness values shown in the table indicate the $/Mg benefit required for VOC emissions in nonattainment areas in order for all benefits to equal costs.

In earlier analyses in this document, an exemption level of 10,000 gallons per month for non-independents and less than 50,000 gallons per month for independents was shown on all tables. The 50,000 gallon per month exemption was based on the requirements set on EPA under Section 325(a) of the Clean Air Act. However, Section 325(b) indicates States are not limited by this exemption level and can require controls for independents less than 50,000 gallons per month through their State Implementation Plans. Therefore, this part of the analysis also shows the impacts of other exemption levels (<2,000 and <10,000 gallons per month for all stations).

3.5 STAGE II AND ONBOARD IMPACTS IN SELECTED AREAS

Several analyses were conducted to focus on the impacts of Stage II and onboard refueling control strategies in different selected areas. The areas evaluated were nationwide and two of the nonattainment area groupings described in Section 2.3.3 of Chapter 2 (27 and 61 areas).

As discussed in Section 2.3.3.1 of Chapter 2, the assumptions concerning the start dates and the schedule to complete equipment installation for nonattainment strategies were evaluated, and three potential start date/phase-in scenarios (low, moderate, and

Table 3-11. COST EFFECTIVENESS OF VOC REDUCTIONS IN NA AREAS CONSIDERING OTHER BENEFITS ($/Mg)

	27 Areas	61 Areas
Onboard (Incremental to Evap)[a]		
NA area VOC reduction only	3,470	2,170
In NA areas, if benzene incidence reductions are valued at $7.5 MM	3,020	1,880
In NA areas, if $250/Mg benefit for AA reduction and benzene incidence reduction is valued at $7.5 MM	2,240	1,490
In NA areas, if $250/Mg benefit for AA reduction, and benzene and ≥ C-6 incidence reductions are valued at $7.5 MM	1,210	850
In NA areas, if $250/Mg benefit for AA reduction and benzene and total vapors incidence reductions are valued at $7.5 MM	[Benefit][b]	[Benefit][b]

Stage II (Exempt <2,000)[c]	In 27 or 61 Areas
NA area VOC reduction only	1,670-1,350
In NA areas, if benzene incidence reductions are valued at $7.5 MM	1,560-1,240
In NA areas, if benzene and ≥ C-6 incidence reductions are valued at $7.5 MM	1,280-960
In NA areas, if benzene and total vapors incidence reductions are valued at $7.5 MM	440-120

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Table 3-11. COST EFFECTIVENESS OF VOC REDUCTIONS IN NA AREAS CONSIDERING OTHER BENEFITS
($/Mg)
(concluded)

Stage II (Exempt <10,000)[c]	In 27 or 61 Areas
NA area VOC reduction only	1,140 - 910
In NA areas, if benzene incidence reductions are valued at $7.5 MM	1,030 - 800
In NA areas, if benzene and ≥ C-6 incidence reductions are valued at $7.5 MM	750 - 520
In NA areas, if benzene and total vapors incidence reductions are valued at $7.5 MM	[Benefit][b]

Stage II (Exempt <10, <50)[c]	In 27 or 61 Areas
NA area VOC reduction only	1,080 - 850
In NA areas, if benzene incidence reductions are valued at $7.5 MM	970 - 740
In NA areas, if benzene and ≥ C-6 incidence reductions are valued at $7.5 MM	640 - 460
In NA areas, if benzene and total vapors incidence reductions are valued at $7.5 MM	[Benefit][b]

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[a] Cost effectiveness values for onboard in selected nonattainment areas (27 or 61 areas) assumes onboard costs borne nationally but VOC emission reductions credited only in the selected areas.

[b] [Benefit] = Benefits outweigh the costs.

[c] Range from minimal enforcement with high difficulty implementation phase-in to annual enforcement with low difficulty implementation phase-in.

NA = nonattainment. AA = attainment area.

high difficulty) were examined. The low difficulty scenario maintains the 3-year equipment phase-in used in the 1984 analysis. The moderate difficulty scenario has the same Federal Register announcement date, but assumes that the implementation of the regulation would take about 6 months longer than the low difficulty scenario. The moderate difficulty scenario also assumes a 3-1/2-year equipment phase-in. The high difficulty scenario assumes a start date 1 year later than the moderate difficulty scenario and includes a 5-1/2-year equipment phase-in. In addition, as noted in Section 3.4, three service station size exemptions are shown on the tables, instead of just one, to provide information on more stringent exemption levels.

3.5.1 Onboard and Stage II in Selected Nonattainment Areas

Table 3-12 illustrates the emission reduction, cost, and cost effectiveness impacts for onboard and Stage II strategies. The table also shows the impacts of various exemption levels for Stage II. As indicated in the table, lower exemption levels can achieve higher emission reductions and incidence reductions but at a higher cost effectiveness. In addition, the costs for service stations on the margin become significantly higher as the exemption level becomes smaller. For example, the cost effectiveness for Stage II controls at a 2,000 gallon-per-month station is $13,000-$10,500/Mg while the cost effectiveness for a 50,000 gallon-per-month station is $1,400-$1,000/Mg. Figures 3-1 and 3-2 illustrate the percent emission reduction with time for onboard in nonattainment areas compared to two Stage II exemption levels. Figures are shown for percent reduction of refueling-only emissions and percent reduction of refueling-plus-emptying emissions.

3.5.2 Combination of Onboard and Stage II in Selected Nonattainment Areas

Figure 3-3 illustrates the emission reduction impacts of combining Stage II and onboard control strategies. The example shown in the figure is for Stage II and onboard emission reductions in nonattainment areas. Stage II is assumed installed for one 8 year equipment cycle since, at the end of this first cycle, onboard emission reductions are nearly equal to Stage II. At that time, it is assumed that the Stage II equipment is not replaced. Table 3-13 summarizes the impacts of a Stage II requirement incremental to onboard controls. Emission reductions and incidence reductions are shown for the 8-year cycle analyzed. Costs, however, are annualized over the entire 33-year analysis.

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Table 3-12. SUMMARY OF ONBOARD AND STAGE II IMPACTS IN SELECTED AREAS

	Incidence Reduction (Bz + GV)		Average Annual Emission Reduction, 10^3 Mg/yr	Annualized Emission Reduction, 10^3 Mg/yr	Annualized Cost, $Million	Cost Effectiveness, $/Mg
	Average Annual	Annualized				
Onboard (Incremental to Evap)						
- 49-State	42	31	280	210	180	850
- 61 Areas	16	12	110	81	180	2,170[a]
- 27 Areas	10	8	68	50	180	3,470[a]
Stage II[b]						
o Nationwide[c]						
- Exempt < 2,000	31-45	26-41	230-330	210-300	320-390	1,660-1,300
- Exempt <10,000	29-42	25-38	220-310	200-280	200-240	1,110- 860
- Exempt <10,<50	25-35	21-32	180-260	160-230	170-190	1,060- 810
o 61 Areas[d]						
- Exempt < 2,000	14-22	11-23	83-130	68-140	110-190	1,670-1,350
- Exempt <10,000	13-20	10-21	78-120	64-130	73-120	1,140- 910
- Exempt <10,<50	11-17	9-18	66-100	54-110	58-92	1,080- 850
o 27 Areas[d]						
- Exempt < 2,000	9-14	7-15	54-86	44-91	74-120	1,670-1,350
- Exempt <10,000	8-13	7-14	51-81	42-85	48-77	1,140- 910
- Exempt <10,<50	7-11	6-11	43-67	35-70	38-60	1,080- 850

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[a] Cost effectiveness values for onboard in selected nonattainment areas (27 or 61 areas) assumes onboard costs borne nationally but VOC emission reductions credited only in the selected areas.

[b] In-use cost effectiveness for service stations on the margin of exemption levels is as follows: 2,000 gal/mon - $13,600-$10,800/Mg, 10,000 gal/mon - $3,200-$2,300/Mg, 50,000 gal/mon - $1,400-$1,100/Mg

[c] Range of values for Stage II - Nationwide is from minimal enforcement, 7-year phase-in to annual enforcement, 3-year phase-in.

[d] Range of values for Stage II in nonattainment areas is from minimal enforcement, high difficulty phase-in to annual enforcement, low difficulty phase-in.

Figure 3-1. PERCENT VOC EMISSION REDUCTION

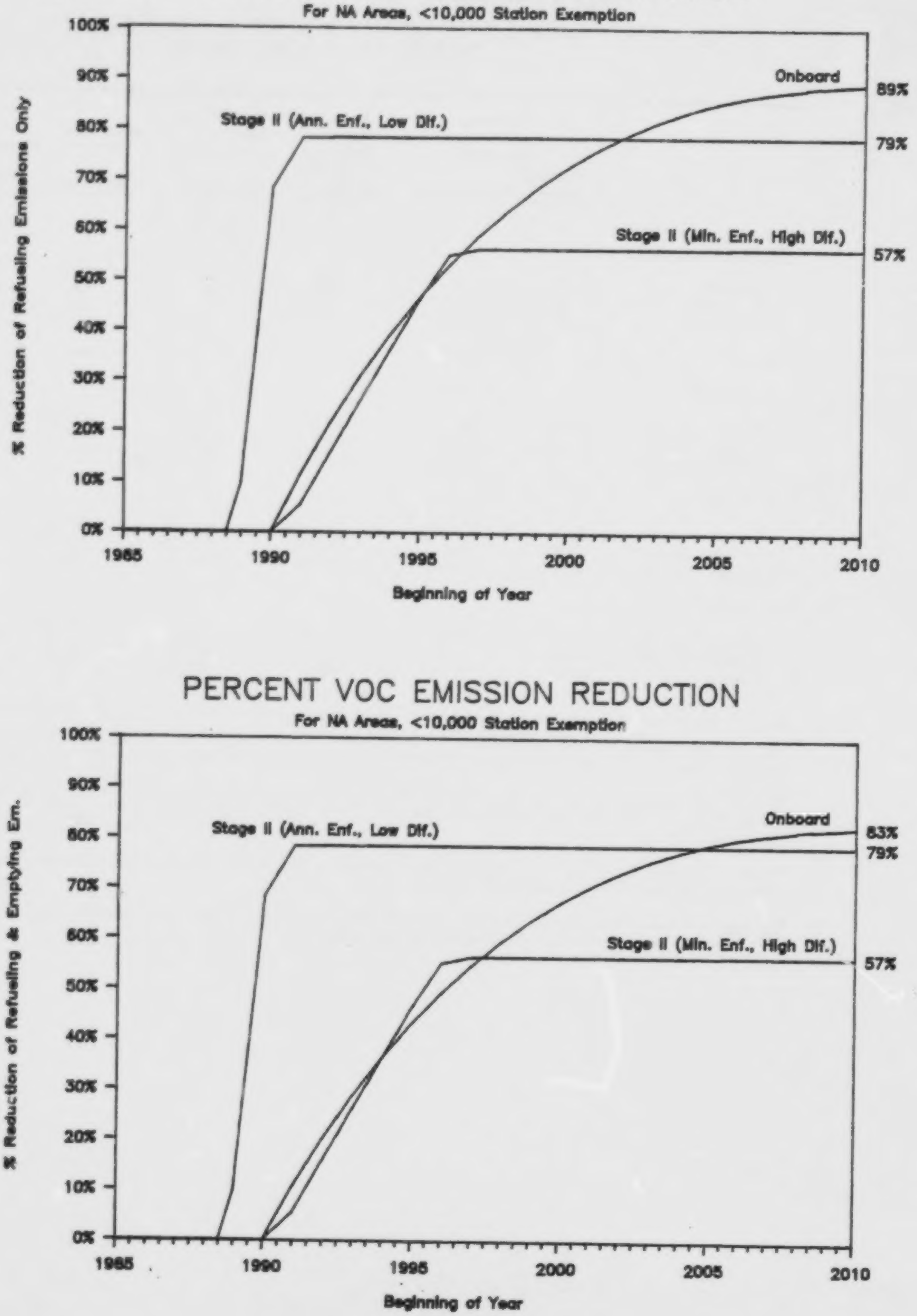
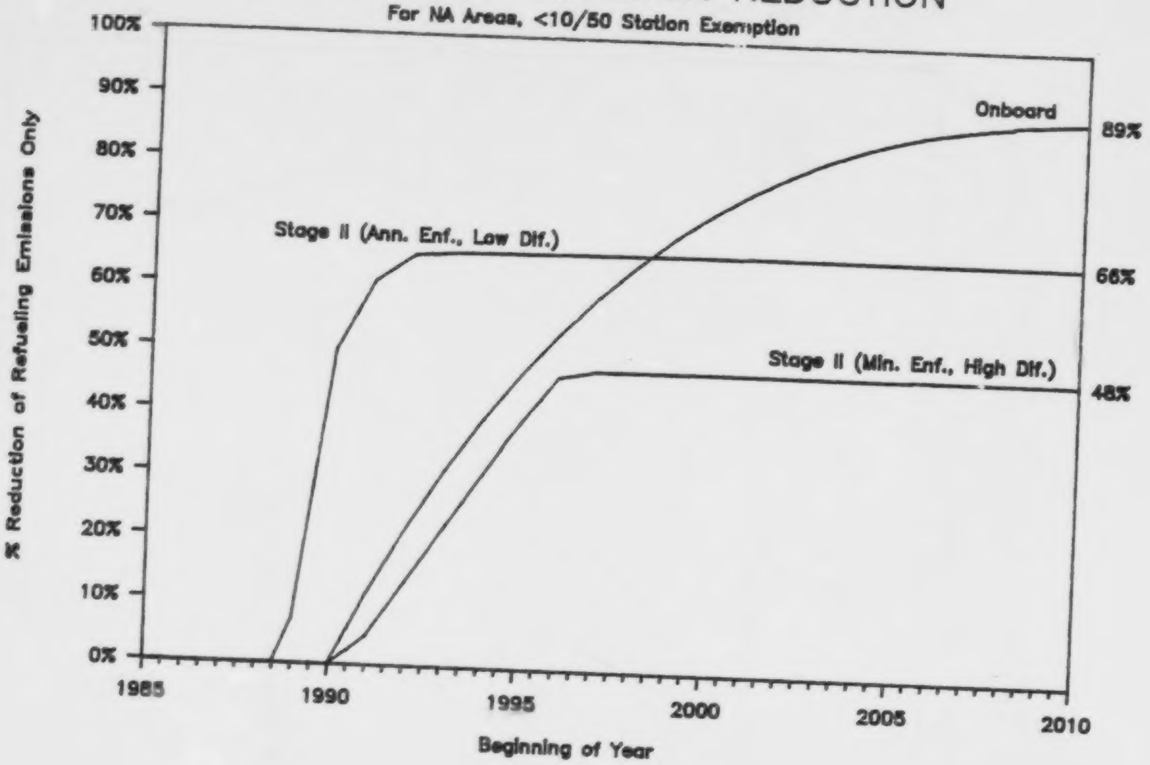


Figure 3-2. PERCENT VOC EMISSION REDUCTION



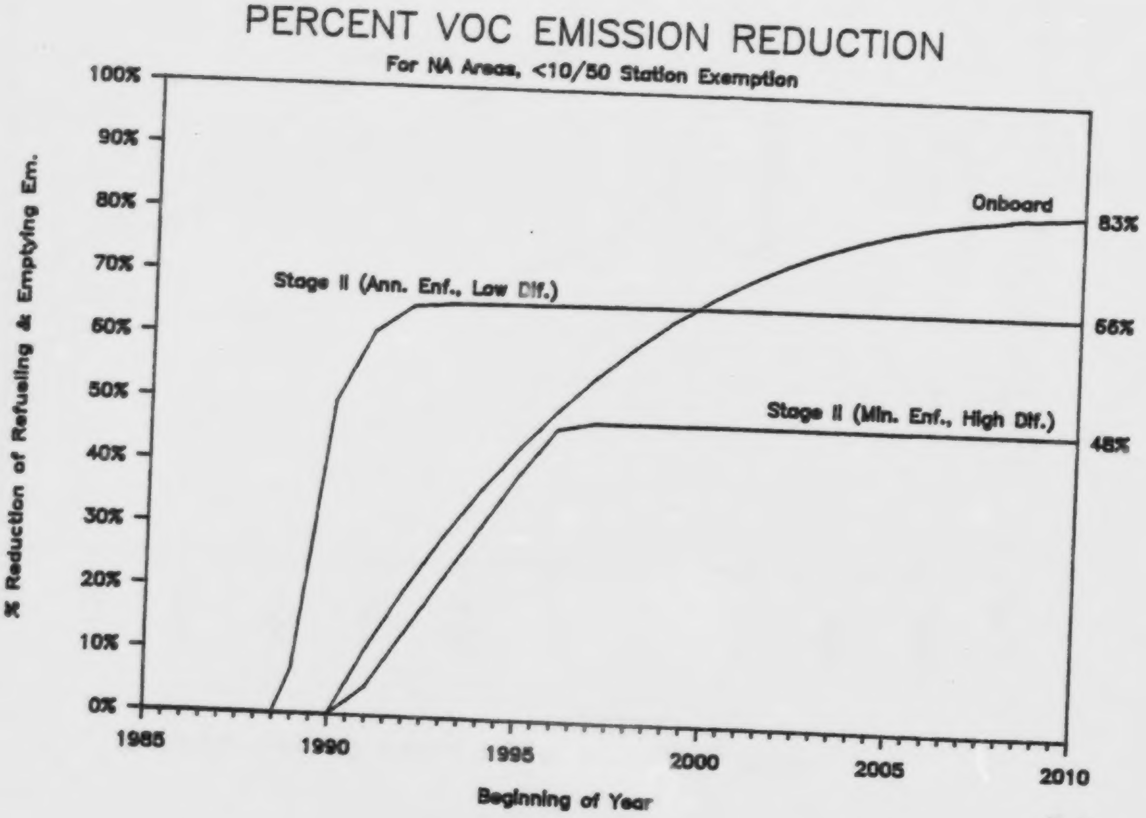


Figure 3-3. PERCENT VOC EMISSION REDUCTION

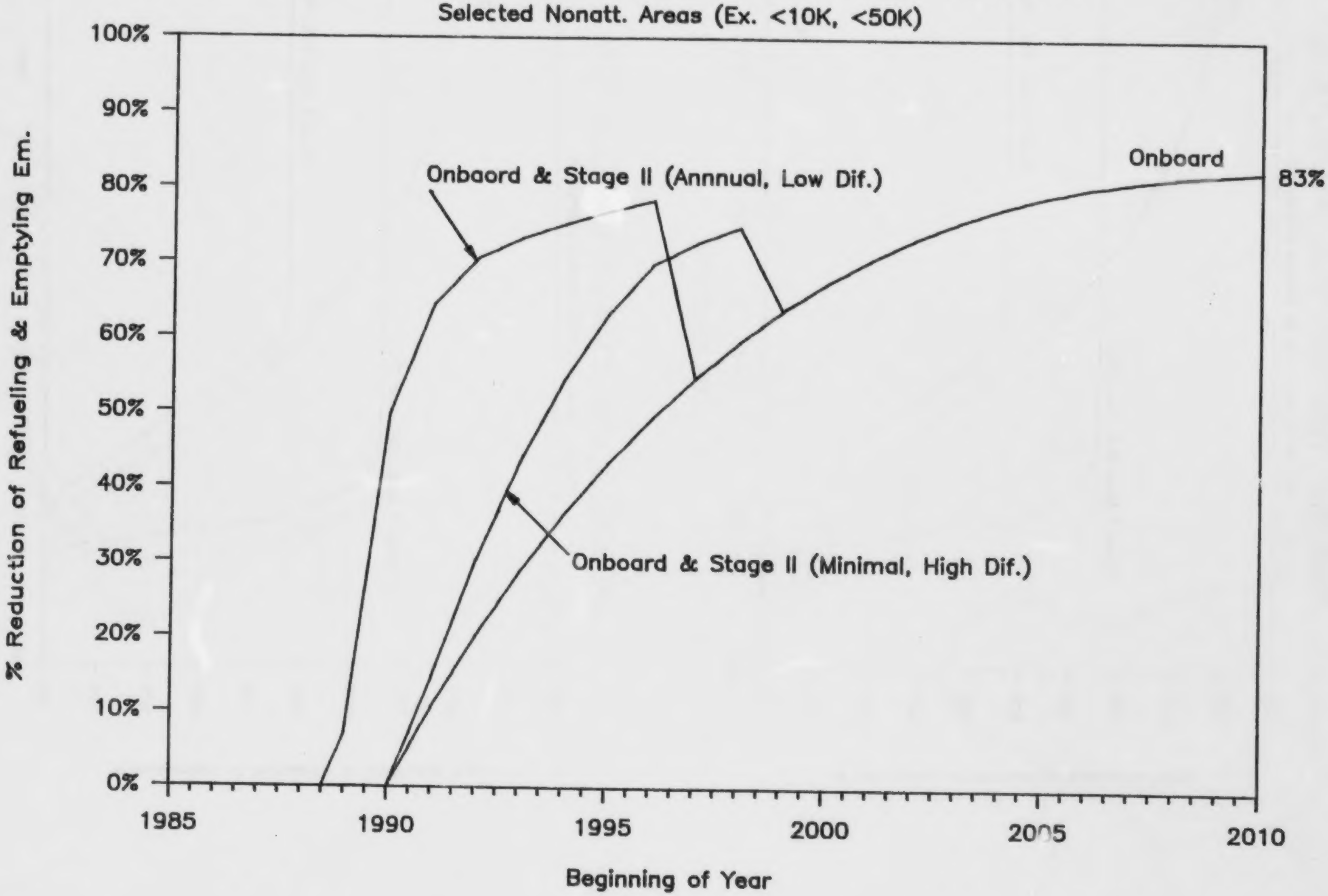


Table 3-13. INCREMENTAL ANALYSIS OF STAGE II IN NA AREAS (INCREMENTAL TO ONBOARD)

Number of Nonattainment Areas Covered by Stage II	Annual Incidence Reduction Over 8 Yrs. (Bz + GV)	Annual VOC Emission Reduction Over 8 Yrs, 10^3 Mg/yr	Annualized Cost, $MM/yr	$/Mg Reduced	$MM/ Incidence @ $0/Mg VOC
11 Areas					
- Exempt <2,000	2-6	14-37	36-62	5,570-2,700	41-18
- Exempt <10,000	2-6	13-35	25-41	4,080-1,920	30-13
- Exempt <10,<50	2-5	11-28	20-32	3,920-1,860	29-12
27 Areas					
- Exempt <2,000	3-9	21-58	56-95	5,510-2,660	41-18
- Exempt <10,000	3-9	20-54	38-63	4,040-1,900	30-13
- Exempt <10,<50	2-7	17-43	31-49	3,880-1,840	29-12
61 Areas					
- Exempt <2,000	5-14	32-89	85-150	5,510-2,660	41-18
- Exempt <10,000	5-14	30-83	59-97	4,040-1,900	30-13
- Exempt <10,<50	4-11	25-67	47-75	3,880-1,840	29-12

[a] Ranges reflect minimal enforcement with high-difficulty implementation phase-in to annual enforcement with low-difficulty implementation phase-in.

Aboveground equipment is amortized over the 8-year equipment cycle but underground piping, purchased at the installation period, is amortized over the 35-year lifetime of the piping. The example shown in Figure 3-3 and Table 3-13 indicates the costs associated with this combination, and how the combination of the two strategies may increase emission reduction in the initial years of the analysis.

3.6 SENSITIVITY ANALYSES

3.6.1 Sensitivity to Various Cost Assumptions for Stage II and Onboard

A sensitivity analysis for Stage II and onboard costs was conducted to determine the impacts on the results of the analysis of using the high and low ends of the cost range. For Stage II costs, ranges were developed that reflected the high and low cost estimates for system components (e.g., nozzles, swivels, coaxial hoses, etc.) and variations in the distances from the underground tanks to the dispensers (affects underground piping and trenching costs). These high, low, and best per-facility cost estimates were then run through the analysis. Table 3-14 summarizes the results of the cost sensitivity analysis for Stage II systems.

Table 3-15 summarizes the cost sensitivity analysis for onboard. The onboard cost range was developed from the onboard hardware costs and the range of onboard recovery credits. The low end of the onboard cost range reflected the low onboard hardware costs (based on a small variation in costs) and the high end of the recovery credits. The best estimate costs were based on the high end of both the hardware costs and the recovery credits. The high cost estimate was based on the high hardware cost and the low recovery credit value.

Table 3-16 summarizes the cost sensitivity results for Stage II in nonattainment areas incremental to a nationwide onboard decision.

Table 3-17 summarizes the benefits, in a similar fashion to Table 3-11, for the best cost estimates for a nationwide Stage II or onboard decision. [See Section 3.4 for more discussion of this Table.]

3.6.2 Inconvenience Cost Sensitivity Analysis

In addition to the facility cost sensitivity analysis, Stage II costs were further evaluated to consider "inconvenience" costs. Inconvenience costs are those additional consumer costs associated with handling the heavier, bulkier and different Stage II vapor recovery nozzles compared

Table 3-14. STAGE II COST SENSITIVITY ANALYSIS[a]

Regulatory Strategy/ Risk Estimate/Cost Estimate	Annual Incidence Reduction (Bz + GV)	Annual VOC Emission Reduction (10^3 Mg/yr)	Annualized Cost[b] ($MM/yr)	$/Mg Reduced	$MM/ Incidence @$0/Mg VOC	$MM/ Incidence @$250/Mg VOC	$MM/ Incidence @$500/Mg VOC	$MM/ Incidence @$1,000/Mg VOC	$MM/ Incidence @$1,500/Mg VOC
STAGE II-NA (11 Areas)									
Total Vapors									
Low Cost Estimate	5-7	28-44	21-33	930-730	6-4	4-3	3-1	(0)	(0)
Best Cost Estimate	5-7	28-44	25-39	1,100-870	7-5	5-4	4-2	0.6-(0)	(0)
High Cost Estimate	5-7	28-44	29-46	1,290-1,020	8-6	6-5	5-3	2-0.1	(0)
≥C-6 Fraction									
Low Cost Estimate	1.5-2.3	28-44	21-33	930-730	18-14	13-9	8-4	(0)	(0)
Best Cost Estimate	1.5-2.3	28-44	25-39	1,100-870	21-16	16-12	11-7	2-(0)	(0)
High Cost Estimate	1.5-2.3	28-44	29-46	1,290-1,020	24-19	20-14	15-10	5-0.4	(0)
Benzene Only									
Low Cost Estimate	0.4-0.7	28-44	21-33	930-730	62-48	45-32	29-15	(0)	(0)
Best Cost Estimate	0.4-0.7	28-44	25-39	1,100-870	73-57	56-41	40-24	7-(0)	(0)
High Cost Estimate	0.4-0.7	28-44	29-46	1,290-1,020	86-67	69-50	53-34	19-1	(0)
STAGE II-NA (27 Areas)									
Total Vapors									
Low Cost Estimate	7-11	43-67	32-51	910-720	6-4	4-3	3-1	(0)	(0)
Best Cost Estimate	7-11	43-67	38-60	1,080-850	7-5	5-4	4-2	0.5-(0)	(0)
High Cost Estimate	7-11	43-67	45-70	1,270-1,000	8-6	6-5	5-3	2-0	(0)
≥C-6 Fraction									
Low Cost Estimate	2-4	43-67	32-51	910-720	17-14	13-9	8-4	(0)	(0)
Best Cost Estimate	2-4	43-67	30-50	1,080-850	21-16	16-12	11-7	2-(0)	(0)
High Cost Estimate	2-4	43-67	45-70	1,270-1,000	24-19	20-14	15-10	5-0	(0)
Benzene Only									
Low Cost Estimate	0.6-1	43-67	32-51	910-720	62-48	45-31	28-15	(0)	(0)
Best Cost Estimate	0.6-1	43-67	38-60	1,080-850	72-57	56-40	39-24	5-(0)	(0)
High Cost Estimate	0.6-1	43-67	45-70	1,270-1,000	86-67	69-50	52-34	18-2	(0)
STAGE II-Nationwide									
Total Vapors									
Low Cost Estimate	25-35	180-260	140-160	900-680	7-5	5-3	3-1	0.1-(0)	(0)
Best Cost Estimate	25-35	180-260	170-190	1,060-810	8-6	6-4	4-2	0.5-(0)	(0)
High Cost Estimate	25-35	180-260	190-220	1,250-950	9-7	7-5	6-3	2-(0)	(0)
≥C-6 Vapors									
Low Cost Estimate	8-12	180-260	140-160	900-680	20-15	15-10	9-4	(0)	(0)
Best Cost Estimate	8-12	180-260	170-190	1,060-810	24-18	18-13	13-7	1-(0)	(0)
High Cost Estimate	8-12	180-260	190-220	1,250-950	28-21	23-16	17-10	7-(0)	(0)
Benzene Only									
Low Cost Estimate	3-4	180-260	140-160	900-680	66-50	47-32	29-13	(0)	(0)
Best Cost Estimate	3-4	180-260	170-190	1,060-810	78-60	60-41	41-23	5-(0)	(0)
High Cost Estimate	3-4	180-260	190-220	1,250-950	92-70	74-52	55-33	19-(0)	(0)

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[a] Ranges of values represent the range of efficiencies achieved between a program of minimal enforcement and an active (annual) enforcement program. For nationwide strategies, the range is from minimal enforcement (7-year phase-in), to annual enforcement (3-year phase-in). For nonattainment area strategies, the range is from minimal enforcement, high-difficulty phase-in to annual enforcement, low-difficulty phase-in.

[b] If an inconvenience cost of 0.3¢/gal is assumed, the Stage II costs would double, resulting in a doubling of all cost effectiveness values (see Section 3.6.2).

Table 3-15. ONBOARD COST SENSITIVITY ANALYSIS (INCREMENTAL FROM EVAP)

Regulatory Strategy/ Risk Estimate/Cost Estimate	Annual Incidence Reduction	Annual VOC Emission Reduction (10^3 Mg/yr)	Annualized Cost ($MM/yr)	$/Mg Reduced	$MM/ Incidence @$0/Mg VOC	$MM/ Incidence @$250/Mg VOC	$MM/ Incidence @$500/Mg VOC	$MM/ Incidence @$1,000/Mg VOC
ONBOARD								
TOTAL VAPORS[a]								
Low Cost Estimate	42	280	140	670	4	3	1	(0)
Best Cost Estimate	42	280	180	850	6	4	2	(0)
High Cost Estimate	42	280	190	920	6	4	3	(0)
$\geq$C-6 FRACTION[a]								
Low Cost Estimate	14	280	140	670	14	9	3	(0)
Best Cost Estimate	14	280	180	850	18	12	7	(0)
High Cost Estimate	14	280	190	920	19	14	9	(0)
BENZENE ONLY								
Low Cost Estimate	4	280	140	670	44	28	11	(0)
Best Cost Estimate	4	280	180	850	56	40	23	(0)
High Cost Estimate	4	280	190	920	61	45	28	(0)

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[a] Total vapors represents benzene plus gasoline vapors (Bz + GV), while the $\geq C_6$ fraction represents benzene plus $\geq C_6$ GV.

Table 3-16. ONBOARD PLUS STAGE II-NA INCREMENTAL TO ONBOARD: COST SENSITIVITY ANALYSIS[a]

Regulatory Strategy/ Risk Estimate/Cost Estimate[b]	Annual[c] Incidence Reduction	Annual[c] VOC Emission Reduction (10^3 Mg/yr)	Annualized Cost ($MM/yr)	$/Mg Reduced	$MM/ Incidence @$500/Mg VOC	$MM/ Incidence @$1,000/Mg VOC	$MM/ Incidence @$1,500/Mg VOC
STAGE II-NA (11 Areas) & ONBOARD							
Total Vapors							
Low Cost Estimate	2-5	11-28	17-28	3,380-1,620	19-10	16-6	12-1
Best Cost Estimate	2-5	11-28	20-32	3,920-1,860	23-13	20-8	16-4
High Cost Estimate	2-5	11-28	25-39	4,790-2,280	29-17	25-12	22-7
≥C-6 Fraction							
Low Cost Estimate	0.5-1	11-28	17-28	3,380-1,620	59-21	49-12	38-2
Best Cost Estimate	0.5-1	11-28	20-32	3,920-1,860	71-26	61-17	50-7
High Cost Estimate	0.5-1	11-28	25-39	4,790-2,280	88-34	78-24	67-15
Benzene Only							
Low Cost Estimate	0.2-0.4	11-28	17-28	3,380-1,620	180-71	150-39	120-8
Best Cost Estimate	0.2-0.4	11-28	20-32	3,920-1,860	220-88	190-56	160-24
High Cost Estimate	0.2-0.4	11-28	25-39	4,790-2,280	280-110	240-81	210-50
STAGE II-NA (27 Areas) & ONBOARD							
Total Vapors							
Low Cost Estimate	2-7	17-43	26-42	3,330-1,600	19-7	16-4	12-0.6
Best Cost Estimate	2-7	17-43	31-49	4,040-1,900	23-8	20-5	16-2
High Cost Estimate	2-7	17-43	38-60	4,730-2,250	29-11	25-8	22-5
≥C-6 Fraction							
Low Cost Estimate	0.8-2	17-43	26-42	3,330-1,600	59-21	49-11	38-2
Best Cost Estimate	0.8-2	17-43	31-49	4,040-1,900	71-26	61-16	50-7
High Cost Estimate	0.8-2	17-43	38-60	4,730-2,250	88-33	78-24	67-14
Benzene Only							
Low Cost Estimate	0.2-0.7	17-43	26-42	3,330-1,600	190-71	150-39	120-6
Best Cost Estimate	0.2-0.7	17-43	31-49	4,040-1,900	230-87	190-55	160-23
High Cost Estimate	0.2-0.7	17-43	38-60	4,730-2,250	280-110	250-81	210-49

[a] Ranges of values represent the range from minimal enforcement, high-difficulty implementation phase-in to annual enforcement, low-difficulty implementation phase-in.

[b] Total vapors represents benzene plus gasoline vapors (Bz + GV), while $\geq C_6$ fraction represents benzene plus $\geq C_6$ GV.

[c] Annual averages are over 8-year Stage II implementation period.

Table 3-17. COST SENSITIVITY IMPACTS ON COST EFFECTIVENESS OF VOC REDUCTIONS IN NA AREAS CONSIDERING OTHER BENEFITS

	$/Mg[a]	
	27 Areas	61 Areas
ONBOARD (INCREMENTAL TO EVAP)		
NA area VOC reduction only	3,470 (3,770-2,730)	2,170 (2,350-1,700)
In NA areas, if benzene incidence reductions are valued at $7.5 MM	3,020 (3,310-2,270)	1,880 (2,070-1,420)
In NA areas, if $250/Mg benefit for AA reduction and benzene incidence reduction is valued at $7.5 MM	2,240 (2,540-1,500)	1,490 (1,580-930)
In NA areas, if $250/Mg benefit for AA reduction and benzene and >C-6 incidence reductions are valued at $7.5 MM	1,210 (1,510-470)	850 (940-290)
In NA areas, if $250/Mg benefit for AA reduction and benzene and total vapors incidence reductions are valued at $7.5 MM	[Benefit][b]	[Benefit][b]

STAGE II (<10,000 Exemption Level)	In 27 or 61 Areas
NA area VOC reduction only	1,140-910 (1,350-760)
In NA areas, if benzene incidence reductions are valued at $7.5 MM	1,030-800 (1,240-640)
In NA areas, if benzene and >C-6 incidence reductions are valued at $7.5 MM	750-520 (960-370)
In NA areas, if benzene and total vapors incidence reductions are valued at $7.5 MM	[Benefit] (120-[Benefit])

[a] Best estimate (High estimate - Low estimate).

[b] [Benefit] = Benefits outweigh the costs.

to conventional refueling equipment. Rather than attempt to quantify this inconvenience cost, an analysis was performed to determine how much inconvenience cost (on a per-gallon basis) would be needed to double the cost effectiveness of the Stage II strategy.

To double the cost effectiveness (assuming a constant emission reduction), the costs associated with the strategy would have to double. The annualized cost of the nationwide Stage II strategy (without evaporative controls) was calculated as \$170-\$190 million (Table 3-1). The average gasoline consumption in the new analysis was about 80 billion gallons per year (see Table 2-4 in Chapter 2) and a Stage II strategy that exempts nonindependents less than 10,000 gallons/month and independents less than 50,000 gallons/month would control about 75 percent of the throughput after full implementation. Therefore, an inconvenience cost of approximately 0.3 ¢ per gallon would double the cost effectiveness of the nationwide Stage II strategy.

3.6.3 Sensitivity to Gasoline RVP Change

In calculating the gasoline vapor emissions from handling operations at bulk terminals, bulk plants, and service stations, the national average value for gasoline RVP of 12.6 psi was used in the emission equations (see Section 2.1 of Chapter 2). The EPA is currently investigating the impacts of a nationwide reduction in RVP during the summer months (ozone season). For purposes of this sensitivity analysis it was assumed that the RVP would be reduced to 9 psi during the five ozone season months (May-September). This case gives a consumption-weighted nationwide (excluding California, which currently controls RVP) annual average RVP of 11.3 psi.

Impacts have been summarized for both RVP assumptions (12.6 and 11.3 psi) and are presented side-by-side for comparison. Table 3-18 presents annual baseline emission estimates for 1984, the 33-year analysis period, and the year 2010. Table 3-19 presents emission reductions, annualized costs, and cost effectiveness figures for onboard, Stage II, and Stage I. In some cases, such as the annualized costs for Stage II, there appears to be no difference between costs for an RVP of 12.6 or 11.3. There is, however, a slight difference that is lost when rounding the values for presentation in the table. Table 3-20 summarizes the cost effectiveness of onboard and Stage II strategies under the two RVP assumptions, considering the benefit value of cancer incidence

Table 3-18. BASELINE EMISSIONS SENSITIVITY TO RVP CHANGE

	Emissions (1,000 Mg/Yr)	
	RVP = 12.6[a]	RVP = 11.3[a]
o Bulk Terminals		
1984	240	220
33-Year Analysis	200	180
In 2010	190	170
o Bulk Plants		
1984	170	160
33-Year Analysis	140	130
In 2010	140	130
o Service Station Stage I		
1984	240	220
33-Year Analysis	200	180
In 2010	190	180
o Service Station Stage II		
1984	530	470
33-Year Analysis	440	390
In 2010	430	380
o Total Baseline		
1984	1,200	1,100
33-Year Analysis	980	880
In 2010	950	860

[a] National average.

Table 3-19. COMPARISON OF STAGE II AND ONBOARD IMPACTS UNDER TWO AVERAGE GASOLINE RVP's (33-YEAR ANALYSIS)

Regulatory Strategy	Average Annual VOC Emission Reduction, 10^3 Mg/yr		Annualized Costs Including Enforcement, $ Million/yr		Cost Effectiveness, $/Mg VOC Reduced	
	RVP=12.6	RVP=11.3	RVP=12.6	RVP=11.3	RVP=12.6	RVP=11.3
Unboard (Incremental to Evap						
49-State	280	250	180	190	850	1,040
61 Areas	110	97	180	190	2,170	2,690
Stage II[a]						
Nationwide[b]						
- Exempt <2,000	230-330	200-300	320-390[d]	320-390[d]	1,660-1,300	1,860-1,460
- Exempt <10,000	210-310	190-280	200-240	200-250	1,110-860	1,260-980
- Exempt <10, <50	180-260	160-230	170-190	170-190	1,060-810	1,200-920
61 Areas[c]						
- Exempt <2,000	83-130	75-120	110-190	110-200	1,670-1,350	1,940-1,570
- Exempt <10,000	78-120	70-110	73-120	74-130	1,140-910	1,340-1,060
- Exempt <10, <50	66-100	59-88	58-92	59-95	1,080-850	1,260-1,000
Stage I	310	280	74	76	260	290

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[a] In-use cost effectiveness for service stations on the margins of exemption levels is as follows: 2,000 gal/mo, $13,600-$10,800/Mg; 10,000 gal/mo, $3,200-$2,300/Mg; 50,000 gal/mo, $1,400-$1,100/Mg.

[b] Ranges of values for Stage II-Nationwide are from minimal enforcement (7-year phase-in) to annual enforcement (3-year phase-in).

[c] Ranges of values for Stage II in nonattainment areas are from minimal enforcement, high-difficulty implementation phase-in to annual enforcement, low-difficulty implementation phase-in.

[d] Cost differences between 12.6 RVP and 11.3 RVP are 2-3%. This difference is lost in rounding the numbers for presentation in the table.

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Table 3-20. RVP IMPACTS ON COST EFFECTIVENESS OF VOC REDUCTIONS IN NA AREAS CONSIDERING OTHER BENEFITS ($/Mg)

Onboard (Incremental to Evap)	61 Areas 12.6 RVP	61 Areas 11.3 RVP
NA area VOC reduction only	2,170	2,690
In NA areas, if benzene incidence reductions are valued at $7.5 MM	1,880	2,370
In NA areas, if $250/Mg benefit for AA reduction and benzene incidence reduction is valued at $7.5 MM	1,490	1,980
In NA areas, if $250/Mg benefit for AA reduction, and benzene and > C-6 incidence reductions are valued at $7.5 MM	850	1,260
In NA areas, if $250/Mg benefit for AA reduction and benzene and total vapors incidence reductions are valued at $7.5 MM	[Benefit][a]	[Benefit][a]

	High-Low Difficulty[b]	
Stage II (Exempt <10,000)	In 27 or 61 Areas 12.6 RVP	In 27 or 61 Areas 11.3 RVP
NA area VOC reduction only	1,140-910	1,340-1,060
In NA areas, if benzene incidence reductions are valued at $7.5 MM	1,030-800	1,210-940
In NA areas, if benzene and $\geq$ C-6 incidence reductions are valued at $7.5 MM	750-520	890-620
In NA areas, if benzene and total vapors incidence reductions are valued at $7.5 MM	[Benefit][a]	[Benefit][a]

[a] [Benefit] = Benefits outweigh the costs.

[b] Range from minimal enforcement with high difficulty implementation phase-in to annual enforcement with low difficulty implementation phase-in.

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reductions. The change in impacts due to this RVP change would be quite small; the cost effectiveness is slightly worse for all strategies under the lower RVP assumption.

3.6.4 Comparison of 49-State and 50-State Onboard Strategy

As a further sensitivity analysis, a comparison was made between an onboard strategy for 49 States (all States except California) and for all 50 States. Table 3-21 contains a summary of the assumptions included in both the 49-State and 50-State onboard analyses. Table 3-22 summarizes the results of the comparison of these two strategies incremental from an excess evaporative strategy. The costs, emission reductions, and cost effectiveness are essentially the same for each strategy. On the surface, it would appear that the 50-State onboard costs should be higher. However, the added cost of onboard on cars in California is offset by the cost benefits associated with removing existing Stage II in California (i.e., elimination of Stage II maintenance and enforcement costs).

For emissions, the 50-State onboard strategy would achieve somewhat more emission reduction than the 49-State strategy after full implementation is achieved, because of onboard's greater in-use efficiency. However, when the emission reduction is calculated on an average annual or annualized basis, the additional long-term emission reduction associated with onboard is offset by the longer phase-in associated with onboard controls.

3.6.5 Impact of Onboard Start-Date

Table 3-23 presents the impacts of delaying the implementation of the onboard strategy by 1 year, from the 1989 to the 1990 model year. The table indicates that the emissions and incidence reductions and costs differ only slightly between these two assumptions. Furthermore, the difference in cost effectiveness is small enough to be lost in the rounding off process.

Table 3-21. SUMMARY OF ASSUMPTIONS USED IN 49-STATE and 50-STATE ONBOARD ANALYSES

49-State Onboard	50-State Onboard
o Onboard required on cars in 49 States (California excluded), Stage II is expanded in California to areas now uncontrolled	o Onboard required on cars in 50 States
o Only incremental emission reduction assigned to areas covered by D.C. Stage II (93 vs. 62 in-use efficiencies)	o Only incremental emission reduction assigned to areas covered by California (93 vs. 86 in-use efficiency) and D.C. (93 vs. 62 in-use efficiency) Stage II
o Exemptions of <10, <50 are granted for "New" Stage II	
o Enforcement costs for strategy based only on inspections required for new Stage II	
o Stage II in D.C. phases out after one equipment life (8 years)	o Stage II in California and D.C. phases out after one equipment life (8 years)
o Cost credit realized for elimination in D.C. Stage II maintenance costs and enforcement costs after phase-out	o Cost credit realized for elimination of California and D.C. Stage II maintenance costs and enforcement costs after phase out
o Initial cost penalty to D.C. Stage II for decreased recovery credits as onboard phase-in	o Initial cost penalty to California and D.C. Stage II for decreased recovery credits as onboard phase-in
o Emission reduction penalty for loss of underground tank emptying emissions captured by D.C. Stage II	o Emission production penalty floor loss of underground tank emptying emissions captured by California and D.C. Stage II

Table 3-22. COMPARISON OF COVERAGE FOR ONBOARD STRATEGIES
(INCREMENTAL FROM EVAP)

Onboard Strategy	Nationwide Costs ($Millions) Annualized	Nationwide Costs ($Millions) Average Annual	VOC Emission Reductions (10^3 Mg) Annualized	VOC Emission Reductions (10^3 Mg) Average Annual	Cost Effectiveness $/Mg
49-State	175	225	207	277	850
50-State	178	216	207	277	860

Table 3-23. SENSITIVITY OF IMPACTS TO ONBOARD START-DATE

Onboard (Incremental to Evap)	Incidence Reduction (Bz + GV)		Average Annual Emission Reduction, 10^3 Mg/yr	Annualized Emission Reduction, 10^3 Mg/yr	Annualized Cost, $ Million	Cost Effectiveness $/Mg
	Average Annual	Annualized				
o 1989 Start-Date						
- 49-State	44	35	290	230	200	850
- 61 Areas	17	14	110	90	200	2,200
- 27 Areas	11	9	70	56	200	3,480
o 1990 Start-Date						
- 49-State	42	31	280	210	180	850
- 61 Areas	16	12	110	81	180	2,200
- 27 Areas	11	8	68	51	180	3,480

APPENDIX A

ESTIMATION OF IN-USE EFFICIENCY FOR VEHICLE REFUELING

APPENDIX A

ESTIMATION OF IN-USE EFFICIENCY FOR VEHICLE REFUELING

In the analysis published by EPA in July of 1984, a methodology was outlined that estimated the in-use control efficiency of Stage II and onboard control systems. The in-use efficiency estimate for Stage II systems was based on 1978-79 survey data on California and Washington, D.C., Stage II installations. Data were obtained on types and frequencies of malfunctions, defects, and tampering, and estimates were made of the decrease in efficiency that could be expected due to each malfunction or defect. The in-use efficiency estimate for onboard control systems was based on the latest vehicle tampering surveys. The in-use efficiencies assumed in the 1984 EPA analysis were as follows: Stage II (minimal enforcement) - 56 percent, Stage II (annual enforcement) - 86 percent, and onboard - 92 percent.

Many comments were received during the comment period regarding in-use efficiencies. Most comments centered around the Stage II system and the fact that EPA's in-use efficiency estimate did not reflect the latest Stage II technology. Therefore, a search was made to determine if new data existed for updating the estimated in-use efficiency of Stage II and onboard vehicle refueling technologies. The following sections summarize the findings of the new EPA in-use analysis.

A.1 ONBOARD

The July 1984 EPA analysis was based upon the use of an onboard system that incorporated a rigidly installed nozzle/fillneck seal (see Figure A-1). This type of seal is subject to complete failure whenever tampering motivated by fuel switching occurs. This occurs rather frequently as a result of motorists' attempts to remove the fillpipe restrictor that limits loading to unleaded gasoline. As discussed in Section 2.1 of this document, EPA's Office of Mobile Sources has evaluated a new design concept for the onboard control system. The new onboard design, shown in Figure A-2, uses a "J-tube" which forms a liquid seal to contain the vapors during refueling and eliminate any efficiency decrease associated with fuel switching-motivated tampering. The EPA now believes that most manufacturers will utilize the liquid trap

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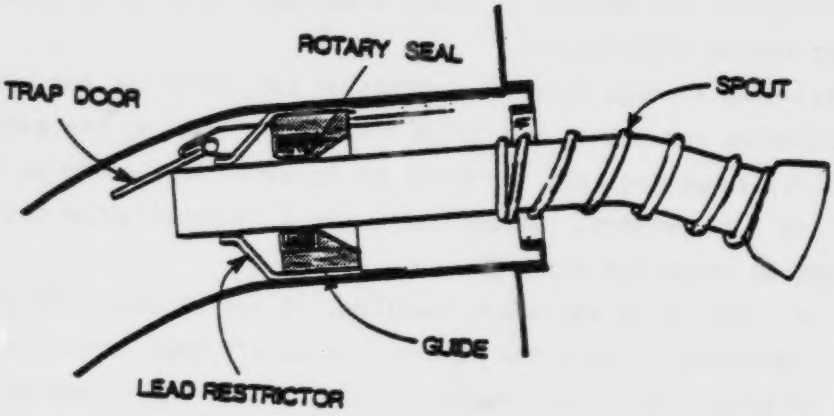
ROTARY SEAL
TRAP DOOR
SPOUT
GUIDE
LEAD RESTRICTOR

Figure A-1. Mechanical Fillneck Seal

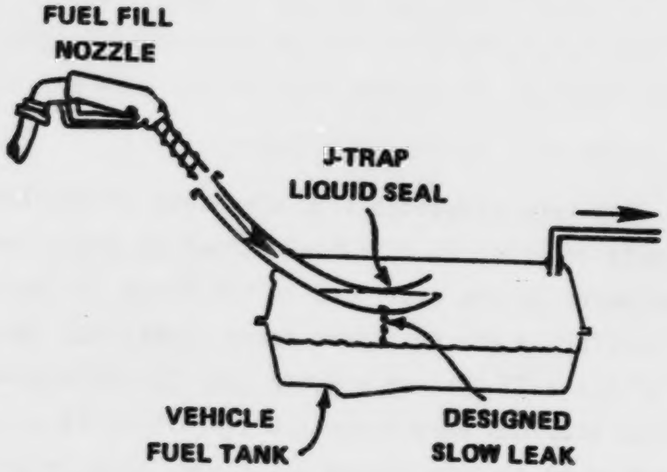
FUEL FILL NOZZLE
J-TRAP LIQUID SEAL
VEHICLE FUEL TANK
DESIGNED SLOW LEAK

Figure A-2. "J-Tube" Fillneck Seal

approach, rather than an elastomer seal, which would virtually eliminate fillpipe tampering as a source of control performance degradation. Therefore, only the charcoal canister and hose tampering rates plus malmaintenance and defects in these areas were used in calculating the revised in-use efficiencies.

Assuming average lifetime periods of 100,000 miles for LDV's, 120,000 miles for LDT's, and 110,000 miles for HDGV's, the average (midpoint) tampering rate for vehicles in each class would be 2.67, 3.29, and 3.12 percent, respectively. On a fleet-weighted basis, this averages to about 2.8 percent.

For purposes of emissions modeling, it was assumed that tampering would completely disable the control system and that control efficiency would be zero. This would happen if the canister were removed or if the feed or purge lines were cut completely. This is clearly conservative, since less severe forms of tampering would not reduce system efficiency as completely.

Tampering has been estimated to reduce the in-use efficiency of onboard controls by about 3.7 percent over the long term (I-B-18). This is not equivalent to a doubling of the 2.8 percent mentioned above, primarily because more fuel is consumed early in the fleet life when tampering rates are low.

To reflect the impacts due to less frequent tampering, the new analysis incorporates an in-use onboard efficiency of 93 percent rather than the 92 percent used in the 1984 EPA analysis.

A.2 STAGE II - ANNUAL ENFORCEMENT

Data were requested from the State of California to update the estimate of Stage II efficiency under an annual enforcement scenario (considered as the upper end of the Stage II in-use efficiency range). The California Air Resources Board (CARB) had recently completed a survey of Stage II systems wherein over 11,000 nozzles at over 1,200 service stations were inspected (I-F-78). Based on this survey, CARB estimated an average in-use efficiency ranging between 80 and 92 percent. However, the data collected could not be separated sufficiently to estimate the in-use efficiency of only third-generation, or latest technology, Stage II control systems. This separation of data would be necessary to satisfy the commenters who felt the in-use efficiency estimate should reflect only the latest technology.

Limited additional data were obtained concerning Stage II inspections in the Bay Area and Ventura County portions of California. These data were considered too limited to form a basis for changing the estimated frequency of defects used to represent the entire State of California.

The CARB also made its own estimates of the decrease in efficiency expected with specific defects. A copy of these estimates was requested to compare or update the estimated efficiency decreases assumed by EPA in its original analysis (I-C-48). The CARB did not use specific values of efficiency decrease associated with defects, but rather used ranges of values. However, the ranges used were so broad (i.e., 0-100, 10-100, etc.) that the calculated efficiency decreases used in the original EPA analysis were still considered to be reasonable estimates.

Since data on the frequency of defects and the efficiency decrease associated with each defect could not be updated, and 86 percent is the midpoint of the CARB range (80 to 92 percent), the revised analysis continues to estimate the upper end of the Stage II in-use efficiency range at 86 percent.

In the July 1984 analysis, the Stage II annual enforcement in-use efficiency was estimated under a "State" enforcement program (88 percent) and under a "Federal" program of enforcement (86 percent). The Federal program in-use efficiency was slightly less because it was assumed the Federal program was a less direct form of inspections (i.e., NOV sent rather than tag out-of-order). Since EPA could not predict the actual mode of enforcement, the analysis is based on the Federal approach (assumed to be the approach used by EPA).

A.3 STAGE II - MINIMAL ENFORCEMENT

Minimal enforcement, or the lower end of the Stage II efficiency range, is based on defects and tampering frequency information gathered in Washington, D.C. In the summer of 1984, EPA completed an inspection program (I-A-61) of every active service station in the Washington, D.C., area. During these inspections, a record was made of the types of defects or tampering found at each station. A total of about 170 service stations were visited and data were gathered on over 1,850 nozzles. It should be noted that since all but one station inspected had balance systems, the data from the Washington, D.C., inspection program could only be used to update the information on balance systems. In addition, difficulties arose in trying to use the published summary data for in-use efficiency calculation purposes. For example, data were summarized separately for instances when the nozzle boot was not installed and when the nozzle face seal was not installed. It could not be determined whether these two defects occurred on one nozzle or two separate nozzles, or how the efficiency decreases of these defects should be combined to determine impacts on all systems. Therefore, the raw data sheets were reanalyzed to produce more useful data summaries for the calculation of in-use efficiencies.

Table A-1 presents the revised summary of defects based on the raw data from the Washington, D.C., inspection program. Also presented in Table A-1 are the estimated efficiency decreases that can be expected with each defect. The following sections describe the categories of defects used in the table.

- Vapor Recovery Equipment Not Installed. Instances where equipment was not installed fell into two categories at the facilities inspected: 1) facilities that had not installed any vapor recovery equipment, and 2) facilities that had installed recovery equipment on some nozzles but not on others. The facilities that had not installed any vapor recovery equipment constituted about 4 percent of all nozzles surveyed. About 9.9 percent of the nozzles surveyed remained uncontrolled even though other nozzles at the same station were controlled. In both cases, an efficiency decrease of 100 percent was assigned to an occurrence of non-installation since no vapor recovery equipment is installed and no capture takes place.
- Nozzle Damage. Twenty-four cases of nozzle damage (1.3 percent of all nozzles) were reported on the raw data sheets. No particulars were given as to the extent of damage or even the type of damage. Since no further data could be obtained from the

Table A-1. BALANCE SYSTEM DEFECTS BASED ON REANALYSIS OF RAW DATA FROM THE WASHINGTON, D.C. STUDY

Defect	No. of Defective Nozzles per total Nozzles Inspected	Percent of all Nozzles	Efficiency Decrease Assigned (percent)
No Vapor Recovery Equipment Installed (non-compliance)	255/1,847	13.8	100
- Facilities with no equipment on any nozzles	73/1,847	4.0	100
- Facilities with at least some vapor recovery	182/1,847	9.9	100
Nozzle Damage	24/1,847	1.3	22
Retractor Not Installed (all other V.R. equipment installed)	331/1,847	17.9	5
Retractor Broken	296/1,847	16.0	5
Boot and Face Seal or Boot Only, Not Installed (V.R. nozzle installed)	77/1,847	4.2	100
Torn Boot	783/1,847	42.4	30
Face Seal Only, Not Installed (remainder of V.R. equipment installed)	12/1,847	0.6	22
Torn Seal	440/1,847	23.8	10
Vapor Hose Not Installed	21/1,847	1.1	100
Torn Vapor Hose	189/1,847	10.2	10
No Seal-No Flow Broken	100/1,847	5.4	22
Insufficient Hose Drainage	72/1,847	3.9	100

inspection report, it was assumed that the decrease in efficiency attributed to this defect (22 percent) would be the same as used in the 1984 EPA analysis for improper nozzle maintenance.

- High Hose Retractor Not Installed. The inspection report documented that 331 nozzles (17.9 percent of the nozzles inspected) did not have high-hang hose retractors installed, even though the remainder of the vapor recovery equipment was in place. The retractors provide counterweight to the nozzle and hose assembly during vehicle refueling and hold the vapor hose upward after completion of refueling to allow proper drainage of any entrained liquid. They were added to the latest Stage II system designs in order to minimize liquid blockage in the vapor hoses. These retractors were installed to enhance emission capture; however, the reduction in efficiency due to the lack of retractors could not be estimated. It was assumed that the efficiency decrease would be similar to that estimated for misinstallation in the 1984 EPA analysis (5 percent). Misinstallations were defined in that analysis as improperly laid vapor piping which resulted in increased backpressure in the vapor line. The backpressure is due to liquid blockage caused by a lack of proper drainback of condensed vapors. It was, therefore, considered appropriate to apply a 5 percent efficiency reduction to the case of non-installation of high-hang hose retractors since the same problem (possible increased backpressure due to liquid blockage in the vapor hose) could occur.
- Retractor Broken. There were a reported 296 cases (16 percent of all nozzles) where the high-hang hose retractor was broken. This defect was assumed to have the same effect on efficiency as the non-installation of the retractor. Therefore, a 5 percent efficiency decrease was assigned to this defect.
- Boot and Face Seal, or Boot Only, Not Installed. The data indicated 77 cases (4 percent of all nozzles) where the vapor recovery nozzle was installed but there was no nozzle boot and face seal installed or, at least, no nozzle boot in place. The nozzle boot surrounds the nozzle spout and acts as the collector of displaced gasoline vapors at the nozzle/fill-

neck interface. Without the nozzle boot, no collection can take place. Therefore, an efficiency decrease of 100 percent was attributed to this defect.

- Face Seal Only, Not Installed. The raw data indicated 12 cases (0.6 percent of all nozzles) where the nozzle face seal was missing, but all other vapor recovery equipment, including the nozzle boot, was installed. The face seal is located at the end of the nozzle boot and provides the primary seal when the nozzle is pushed against the vehicle. Without the face seal, a good seal cannot be made at the nozzle/fillneck interface and some vapors can escape, thus decreasing the efficiency. Since the nozzle boot itself is installed and still functioning, it was assumed that a significant portion of the vapors would still be collected. No quantitative information was available concerning the actual loss in efficiency. It was estimated that the lack of a face seal should cause an even larger decrease in efficiency than the 10 percent decrease in efficiency associated with significant tears in the face seal. Therefore, it was assumed that the efficiency decrease associated with a missing face seal would be the same as that used in the previous analysis for a combination of nozzle boot and face seal tears (22 percent decrease in efficiency).
- Torn Nozzle Boot. The inspection report indicated that 783 cases (42 percent of the nozzles) had some sort of tear in the nozzle boot. There was no additional information on the raw data sheets that specified the length or size of the boot tears. To estimate the efficiency decrease due to this defect, the assumptions used in the previous analysis were maintained. In that analysis, it was assumed that the average nozzle tear was 1.3 inches in length and that the resulting efficiency decrease would be 30 percent.
- Torn Nozzle Face Seal. The raw data from the inspection program documented 440 cases (24 percent of all nozzles) where tears occurred in the nozzle face seal. Again, no quantitative data were available with respect to the average size of a face seal tear. Using the assumptions of the past analysis, an efficiency decrease of 10 percent was attributed to this defect.

- Vapor Hose Not Installed. The raw data from the inspection survey indicated 21 instances (1 percent of all nozzles) where the vapor hose was missing, but all other vapor recovery equipment was installed. Obviously, if the vapor hose is not installed there can be no recovery of vapors. Accordingly, an efficiency decrease of 100 percent was assumed.
- Torn Vapor Hose. During the inspection program a total of 189 cases (10 percent of the nozzles) were found to have torn vapor hoses. As before, no quantitative information was presented on the data sheets to indicate the extent of the hose tears. Therefore, the assumptions used in the 1984 EPA analysis to estimate the efficiency decrease for this defect again had to be assumed. These assumptions led to an efficiency decrease of 10 percent being attributed to this defect.
- No Seal-No Flow Mechanism Broken. A total of 100 cases (5 percent of the nozzles) were reported where the no seal-no flow mechanism was broken. This mechanism forces the user to make a good seal at the nozzle/fillneck interface or no gasoline will flow through the nozzle for dispensing into the vehicle. The seal is accomplished by pushing the nozzle boot firmly against the vehicle. Without the no seal-no flow mechanism, an operator could pump gasoline regardless of whether a proper seal had been made. The decrease in efficiency for this defect could be anywhere from 0 to 100 percent, depending on how hard the operator pushed the nozzle. For calculation purposes, it was assumed that the decrease in efficiency would be the same as that associated with no face seal installed, or 22 percent.
- Insufficient Hose Draining. A total of 72 cases (4 percent of all nozzles) were reported with insufficient hose draining. A clarification from the contractor who performed these tests indicated that insufficient hose draining meant that, in the inspector's judgment, there was sufficient liquid in the vapor return hose to block essentially all vapor passage. The efficiency decrease associated with this defect was, therefore, estimated as 100 percent.

There were several items summarized in the inspection report that were not included in the estimation of in-use efficiency because they were not considered to have a direct effect on efficiency. These items included:

1) Nozzle hangup bracket damaged or not installed - Problems with the hangup bracket may lead indirectly to nozzle or hose damage, but cannot be cited as directly causing decreases in efficiency;
2) Pressure shut-off broken - The pressure shut-off will deactivate the nozzle due to excessive backpressure in the vapor line and, if broken, will continue to pump gasoline. This only becomes a problem when this backpressure failure occurs simultaneously with a liquid blockage problem in the vapor line. Since the causes of liquid blockage were already accounted for in the items included in the calculations, it was felt that the inclusion of this item would cause duplication;
3) Circulation shut-off broken - This pertains to the case when the anti-recirculation mechanism is broken. This failure may allow the recirculation of liquid through the vapor line (given a nozzle shut-off failure). Although gasoline may be inadvertently recirculated through the system, this failure would not, in itself, result in a decrease in the system vapor recovery efficiency;
4) Improper hose placement - The local control agency has a requirement that hoses be placed in such a manner as to minimize the possibility of being run over or damaged by vehicles. Although improperly placing hoses may eventually result in damage to the hoses, the act of improper hose placement by itself does not result in lower efficiency. (The results of improper placement would show up in the hose defect category);
5) Inadequate nozzle removal delay - The local agency also has a requirement that the nozzle be held in the vehicle for 10 seconds after completing refueling. The purpose of this is to balance pressure between the vehicle tank and the

service station tank, thereby minimizing spills and spit-back. The inspectors noted on their inspection sheets instances when the consumer or the attendant failed to wait for the required 10 seconds. Failure to comply with this requirement would not affect the vapor control or collection efficiency of the vapor recovery system.

A.4 CALCULATION OF EFFICIENCY (Minimal Enforcement Case)

Given the frequency of defects and the corresponding efficiency decreases, the in-use efficiency could be calculated for the minimal enforcement case. The following equation was used to estimate the in-use efficiency:

$$\text{Average In-use Efficiency} = E_T\,(100 - (F_1)(ED_1))\,(100 - (F_2)(ED_2))\ldots(100 - (F_x)(ED_x))$$

where:

E_T = Theoretical efficiency (95 percent for balance systems).
F_x = Frequency of occurrence of defect x (percent).
ED_x = Efficiency decrease associated with defect x (percent).

The actual in-use efficiency for a balance system (assuming all equipment installed) was calculated using the equation above and the values in Table A-1 as follows:

$$\begin{aligned}\text{Average In-use Efficiency} &= (0.95)\,[(1.00-(.013)(.22))(1.00-(.179)(.05))\\&\quad(1.00-(.16)(.05))(1.00-(.042)(1.00))\\&\quad(1.00-(.424)(.30))(1.00-(.006)(.22))\\&\quad(1.00-(.238)(.10))(1.00-(.011)(1.00))\\&\quad(1.00-(.102)(.10))(1.00-(.054)(.22))\\&\quad(1.00-(.039)(1.00))]\\&= 0.7057\\&= 70.6 \text{ percent (for balance systems).}\end{aligned}$$

The in-use efficiencies for hybrid systems (78 percent) and for vacuum assist systems (69 percent) were taken from the 1984 EPA analysis since there were insufficient data available from the inspection program to revise these estimates. Given the same relative percentages of systems (80% balance, 15% hybrid, and 5% vacuum assist), the nationwide weighted average in-use efficiency for facilities that have vapor recovery equipment installed on all nozzles would be:

$$\begin{aligned}\text{Weighted Average} &= (0.8)(70.6) + (0.15)(78) + (0.05)(69) \\ &= 71.6 \text{ percent.}\end{aligned}$$

The last step in the in-use efficiency calculation procedure was to include the non-compliance or non-installations in the calculations. The data indicated that at facilities with at least some vapor recovery equipment installed, 9.9 percent of the nozzles had no vapor recovery. Assuming this would apply equally to all system types, the in-use efficiency for those facilities with at least some equipment installed would be:

$$\begin{aligned}\begin{array}{l}\text{In-use Efficiency} \\ \text{For Facilities} \\ \text{With At Least Some} \\ \text{Vapor Recovery} \\ \text{Equipment Installed}\end{array} &= (0.716)\ (1.00 - (.099)(1.00)) \\ &= 64.5 \text{ percent.}\end{aligned}$$

The total nationwide in-use efficiency for the minimal enforcement scenario must also take into account the facilities that have no vapor recovery equipment installed at all. Therefore, the nationwide in-use efficiency for all service stations under a minimal enforcement scenario would be:

$$\begin{aligned}\begin{array}{l}\text{Nationwide} \\ \text{In-use} \\ \text{Efficiency} \\ \text{(Minimal} \\ \text{Enforcement)}\end{array} &= (0.645)\ (1.00 - (.04)(1.00)) \\ &= 62 \text{ percent.}\end{aligned}$$

A.5 REFERENCES

I-A-61 D.C. Gasoline Station Inspections To Assure Compliance With Stage II VOC Vapor Recovery Requirements. U.S. Environmental Protection Agency, Region III. Philadelphia, Pennsylvania. Prepared by Engineering-Science. January 1985.

I-B-18 Glenn W. Passavant, U.S. Environmental Protection Agency, SDSB, to Stephen Shedd, U.S. Environmental Protection Agency, ESED. Cost and Emission Information to Assure Consistency Between Gas Marketing and Evap/RVP Studies. October 7, 1985.

I-C-48 Letter from Norton, Robert, Pacific Environmental Services, Inc., to Morgester, Jim, California Air Resources Board. Request for data on the frequency of Stage II defects. April 5, 1985.

I-F-78 California Air Resources Board. A Report to the Legislature on Gasoline Vapor Recovery Systems for Vehicle Fueling at Service Stations. Sacramento, California. March 1983.

APPENDIX B

STAGE II PER-FACILITY COSTS

APPENDIX B
STAGE II PER-FACILITY COSTS

B.1 INTRODUCTION

Cost data were obtained and developed on a per-facility basis for each model plant size. These per-facility costs were then combined with data on the number of facilities requiring controls within each model plant category so that nationwide costs could be determined.

The Agency obtained cost data from numerous sources (vendors, equipment suppliers, and construction contractors) in determining reasonable estimates for the capital and annualized costs that would be incurred by installation of Stage II vapor recovery systems, due either to retrofit on an existing facility or to the incorporation of controls during construction of a new facility. All data were obtained during the third and fourth quarters of 1984, and these values are taken to represent third quarter 1984 costs. Information for determining Stage II costs was compiled based on vapor recovery systems currently available and certified in California; i.e., the individual balance system, the manifolded balance system, the hybrid system, and two types of vacuum assisted systems. The reasons for using only the systems currently certified in California are that these systems are in actual operation and have been demonstrated to meet the control efficiencies assumed in this analysis, and detailed information is available on the exact components that make up each approved system. The presented per-facility cost estimates are based upon the 95 percent theoretical efficiency since this is the efficiency at which the systems are certified. However, when extrapolating these per-facility costs to nationwide or nonattainment areas, in-use efficiencies are assumed.

Both the individual and manifolded balance systems are considered in this analysis because each is currently certified for use in California and because when the analysis effort was begun the magnitude of the cost difference between the two systems was not known. The cost analysis for the hybrid system is based solely on the Healy System, because this is the only one for which accurate cost data were available. Cost data were not available from the other hybrid manufacturer, Red Jacket, since this company's system is not currently being manufactured. The costs shown for the vacuum assist systems are based on the Hirt system and the Hasstech system. Throughout this appendix, the title Assist-1 is used to denote the Hirt System, Assist-2 is used for the Hasstech System, Hybrid is used for the Healy system, Bal-I is used to indicate an individual balance system, and Bal-M is used for a manifolded balance system.

Several terms are used during the discussion of Stage II capital costs. The "purchase cost" of an item represents the manufacturer's quoted selling price for the item. The "direct cost" of an item equals the item's purchase cost plus the direct expenses incurred during the installation of the item (e.g., labor, materials, and site preparation). The "capital cost" of an item equals the sum of the item's direct cost and its indirect cost (e.g., model study, contingencies, startup). However, since Stage II systems are relatively small and simple, no indirect costs are incurred. Therefore, in this case, the capital cost of an item is the same as its direct cost. The cost components that comprise the "annualized cost" of a Stage II system are defined as they appear later in this discussion.

A summary of the aboveground and underground component cost analysis is presented in Section B.2. Section B.3 presents the per-facility cost results for retrofitting an existing facility, and Section B.4 presents the costs for installation during the construction of a new facility.

B.2 COMPONENT COSTS

This section presents the capital and annualized costs of both the aboveground (B.2.1) and underground (B.2.2) equipment components of a Stage II system retrofitted to an existing service station. This analysis incorporates the conclusion of Appendix I, which evaluated Stage II dispenser configurations. The analysis presented here assumes that all existing and new facilities incorporate coaxial hose configurations and that one-fourth of the existing and three-fourths of the new facilities will incorporate multiproduct dispensers.

The capital cost data for all Stage II vapor recovery systems were re-evaluated and broken down into aboveground costs, which include the costs for dispenser components, and underground costs, which include the installation cost of an underground piping system. The capital recovery cost factor used to calculate annualized costs was based on an equipment life of 8 years for the dispenser and auxiliary equipment, and 35 years for the underground piping system.

B.2.1. Aboveground Costs

To calculate aboveground costs, EPA obtained a list of the aboveground components certified for use in California. The vendors of the components on this list were then contacted to obtain a current retail price for each component. Finally, the price range for each individual component type was averaged to arrive at a single price for each component type.

Table B-1 contains a component list of the equipment necessary to modify an existing dispenser into a balance, or Hirt, Stage II vapor recovery dispenser. This equipment list was obtained from an Executive Order issued by the State of California Air Resources Board (G-70-52-AE: Exhibit 2) (I-F-113)* and represents the equipment certified for use in the Stage II systems. This table provides a list of manufacturers and model numbers for each piece of equipment; other makes of the same equipment are not certified and, thus, may not be used in California. This Executive Order also presents exhibits (Exhibits 4-10) that depict the dispenser configurations that may be used (see Figures B-1, through B-7). Exhibits 8 through 10 depict multi-product dispensers. Multi-product dispensers, which are relatively new, offer three grades of product on each side of the dispenser (six nozzles per dispenser).

B.2.1.1 Dispenser Modification Equipment Costs (Not Including Nozzles)

A specific subset of the component list shown in Table B-1 is applicable to each exhibit, thereby providing a different cost for each exhibit. The manufacturers of the components listed in Table B-1 were contacted to obtain current costs. These costs for each dispenser type are summarized by exhibit number in Table B-2. This table lists the lowest, highest, and average price of each component within each exhibit configuration. In this manner, an average cost has been obtained for the exhibit configurations shown in Figures B-1 through B-7. Based on the conclusions of Appendix I, the cost analysis

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*Numbers indicated in this format are references (Section B.5) and correspond to docket item numbers in Docket No. A-84-07.

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Table B-1. COMPONENT LIST FOR BALANCE OR HIRT STAGE II VAPOR RECOVERY SYSTEMS (from Reference I-F-113)

Item/Manufacturer and Model No.	Exhibit 4	5	6	7	8	9	10
Nozzles							
Emco Wheaton A 3003	X		X	X			
Emco Wheaton A 3005		X	X		X	X	X
Emco Wheaton A 3006	X		X	X			
Emco Wheaton A 3007		X	X		X	X	X
OPW 7V-E (34,36,47,49)	X		X	X			
OPW 7V-H (34,36,47,49, 60-63)	X		X	X			
OPW 11V-C (22,24,47,49)	X	X	X	X	X	X	X
OPW 11V-E (34,36,47,49)	X	X	X	X	X	X	X
High-Retractor Hose Configurations							
Overhead Hose Retractors							
Pomeco 100A, B, C	X	X					
Pomeco 102	X	X					
Petro-Vend PV-8	X	X					
CNI Series 9900, 9910 and 9930	X	X					
Dresser Wayne Model 390-IL						X	
Gasboy Model 90-750-2			X	X	X		
Gilbarco	X	X					
High-Retractor Dispensers							
Dresser Wayne Series 370/380						X	
Dresser Wayne Decade Marketer Series 310/320			X				
Gasboy Series 50				X			
Tokheim Series 162	X	X					
Dresser Wayne Series 390 MGD	X	X					
Tokheim Models 330A and 333A MMD					X X		
High-Hang Hose Configurations							
Dispensers							
Gilbarco MPD						X	X
Coaxial Hose Assembly							
B.F. Goodrich Co-Ax		X	X		X	X	X
Liquid Removal Systems							
Gilbarco Venturi							X

(Table concluded on next page.)

Table B-1. COMPONENT LIST FOR BALANCE OR HIRT STAGE II VAPOR RECOVERY SYSTEMS (from Reference I-F-113) (concluded)

Item/Manufacturer and Model No.	Exhibit						
	4	5	6	7	8	9	10
Swivels							
Nozzle							
Pomeco Model 7	X		X	X			
Husky I-VI	X		X	X			
Emco Wheaton							
A 4110-001(45°)		X			X	X	
A 4113-001(90°)					X	X	
OPW 43	X		X	X			
OPW 43-C (45°)		X			X	X	
OPW 43-T	X		X	X			
OPW 33-CV	X		X	X			
Island							
Emco Wheaton							
A 93-001		X					
OPW 36-C		X					
Dispenser							
Emco Wheaton							
A 4113-001 (90°)					X		
Emco Wheaton							
A 92-001		X					
Wedgon PS 3445 VRM	X		X				
Retractor Swivel							
Searle Leather & Packing B-1399 or State Fire Marshal approved equivalent		X					
Flow Limiter							
Emco Wheaton A-10 or State Fire Marshal approved equivalent	X	X	X	X	X	X	X
Recirculation Traps[a]							
Emco Wheaton							
A 008-001	X	X	X	X			
Emco Wheaton							
A 94-001	X	X	X	X			
Emco Wheaton							
A 95-001	X	X	X	X			
OPW 78, 789-S, 78E, 78-ES	X	X	X	X			

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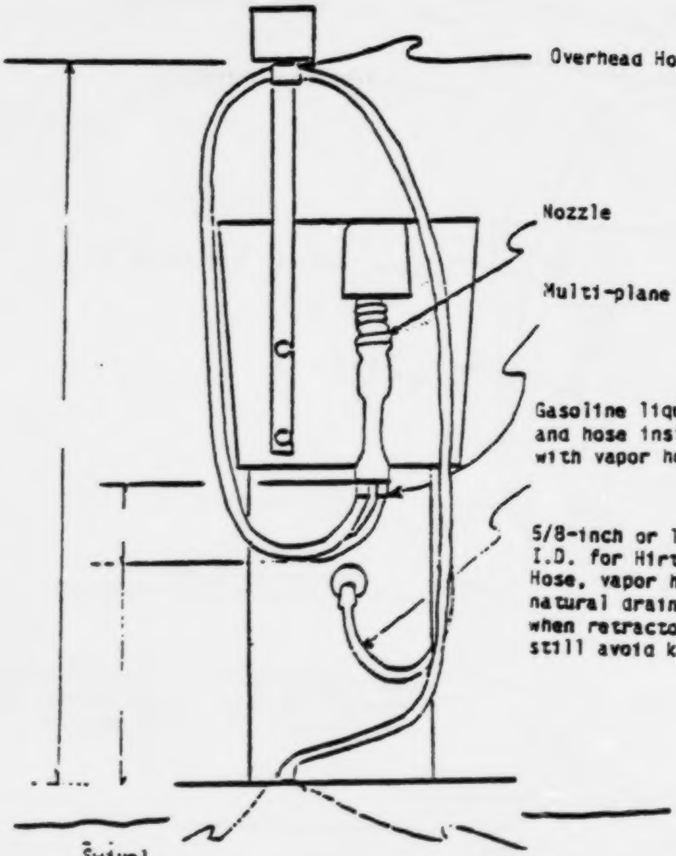
[a] Due to the law in California requiring all balance systems to have high-hang retractors by 1986, recirculation traps will no longer be required after 1986.

Figure B-1. Exhibit-4, Twin Hose Side-Mount High-Retractor Configuration
(from reference I-F-113)



Overhead Hose Retractor

Nozzle

Multi-plane swivel on vapor and liquid hose.

Gasoline liquid hose length shall be selected and hose installed to avoid interference with vapor hose operation.

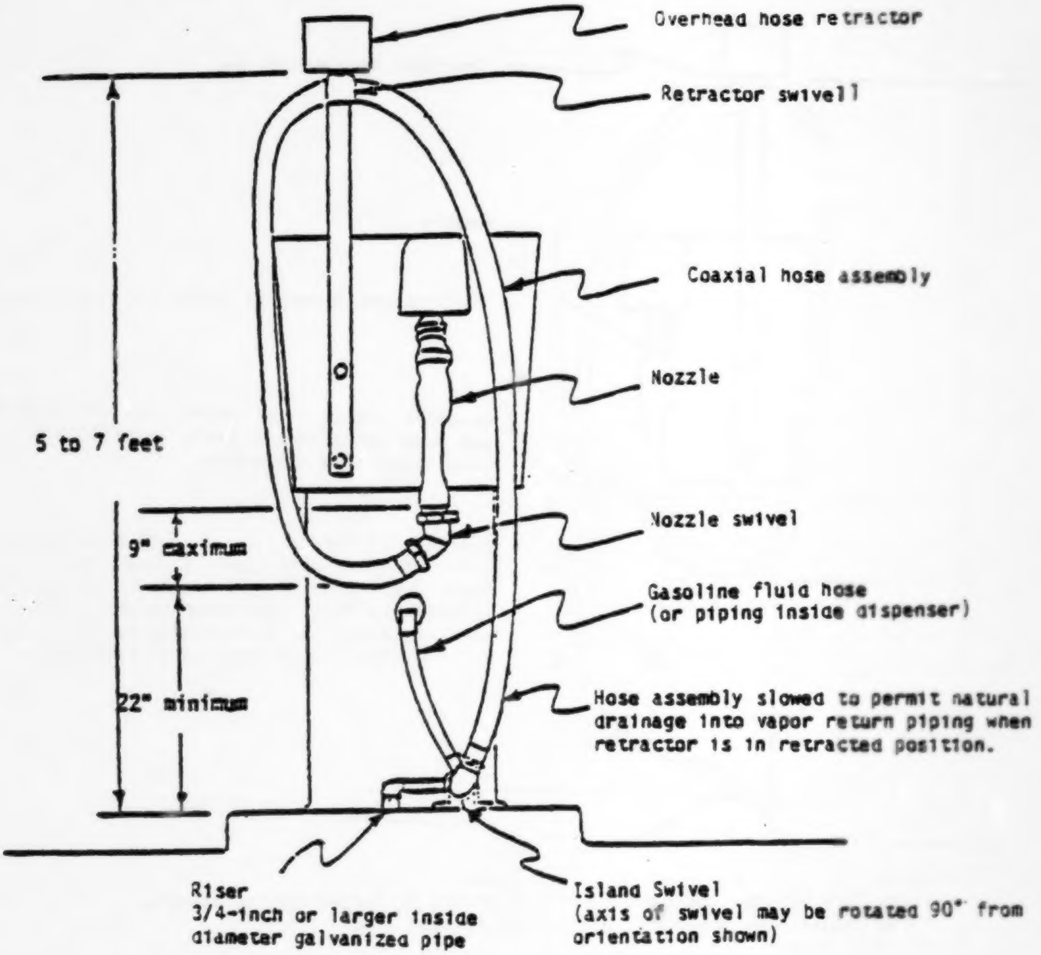
5/8-inch or larger I.D. (3/4 inch or larger I.D. for Hirt system and 12 gpm). Vapor Hose, vapor hose length as needed to permit natural drainage into vapor return piping when retractor is in retracted position, and still avoid kinking when fully extended.

Swivel
State Fire Marshal approved
0.495 inches I.D. minimum
45° with stops

Riser
3/4-inch or larger inside diameter galvanized pipe

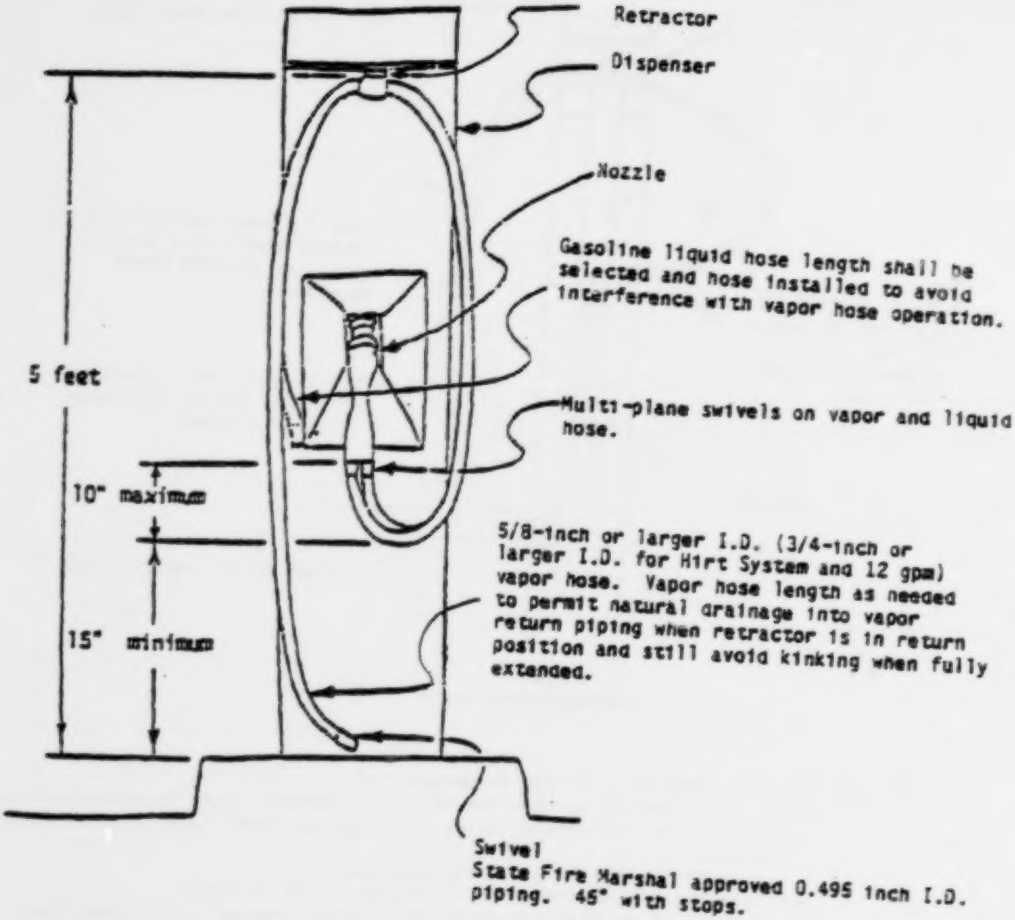
Notes:
1. See Exhibit 2 for the component list.
2. A flow limiter is required on all dispensers using Emco Wheaton nozzles except the Hirt system using Emco Wheaton Model A3096 and 3/4-inch vapor hoses.
3. A recirculation trap is not required.
4. Use appropriate hose ties.
5. Vapor return piping may be installed on the inside or on the outside of the dispenser cabinet.

Figure B-2. Exhibit-5, Coaxial Hose Side-Mount High-Retractor Configuration
(from reference I-F-113)


Overhead hose retractor
Retractor swivel
Coaxial hose assembly
Nozzle
5 to 7 feet
Nozzle swivel
9" maximum
Gasoline fluid hose
(or piping inside dispenser)
22" minimum
Hose assembly sloped to permit natural drainage into vapor return piping when retractor is in retracted position.
Riser
3/4-inch or larger inside diameter galvanized pipe
Island Swivel
(axis of swivel may be rotated 90° from orientation shown)

Notes:
1. See Exhibit 2 for the component list.
2. A flow limiter is required on all dispensers using Emco Wheaton nozzles except the Hirt system using Emco Wheaton Model A3096 and 3/4-inch vapor hoses.
3. A recirculation trap is not required.
4. Vapor return piping may be installed on the inside or on the outside of the dispenser cabinet.

Figure B-3. Exhibit-6, Twin Hose or Coaxial Hose Dispenser-Mount, High-Retractor Configuration
(from reference I-F-113)



Gasoline liquid hose length shall be selected and hose installed to avoid interference with vapor hose operation.

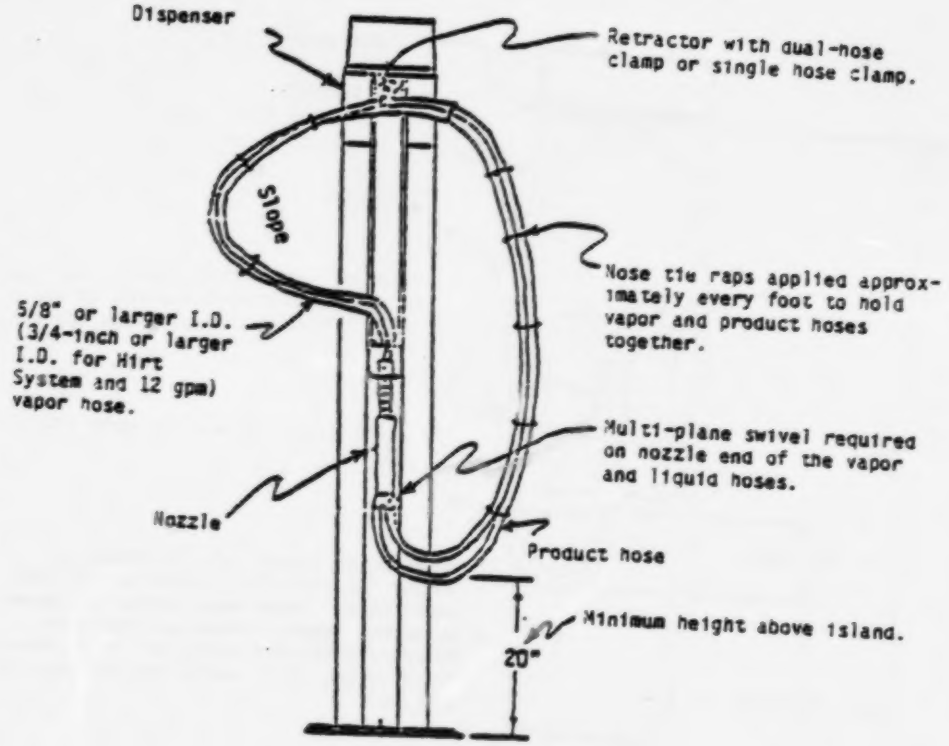
Multi-plane swivels on vapor and liquid hose.

5/8-inch or larger I.D. (3/4-inch or larger I.D. for Hirt System and 12 gpm) vapor hose. Vapor hose length as needed to permit natural drainage into vapor return piping when retractor is in return position and still avoid kinking when fully extended.

State Fire Marshal approved 0.495 inch I.D. piping. 45° with stops.

Notes:
1. See Exhibit 2 for the component list.
2. A flow limiter is required on all dispensers using Emco Wheaton nozzles except the Hirt system using Emco Wheaton Model A3096 and 3/4-inch vapor hoses.
3. A recirculation trap is not required.
4. Use appropriate hose ties.
5. Vapor return piping may be installed on the inside or on the outside of the dispenser cabinet.
6. Riser, 3/4-inch or larger inside diameter galvanized pipe.

Figure B-4. Exhibit-7, Twin Hose Dispenser-Mount, High-Retractor Configuration (from reference I-F-113)


Dispenser
Retractor with dual-hose clamp or single hose clamp.
Slope
Hose tie raps applied approximately every foot to hold vapor and product hoses together.
5/8" or larger I.D. (3/4-inch or larger I.D. for Hirt System and 12 gpm) vapor hose.
Multi-plane swivel required on nozzle end of the vapor and liquid hoses.
Nozzle
Product hose
Minimum height above island.
20"

Notes:
1. See Exhibit 2 for the component list.
2. A flow limiter is required on all dispensers using Emco Wheaton nozzles except the Hirt system using Emco Wheaton Model A3096 and 3/4-inch vapor hoses.
3. A recirculation trap is not required.
4. Hose swivels not required at dispenser end of hoses.
5. Riser must be 3/4-inch or larger inside diameter galvanized pipe.

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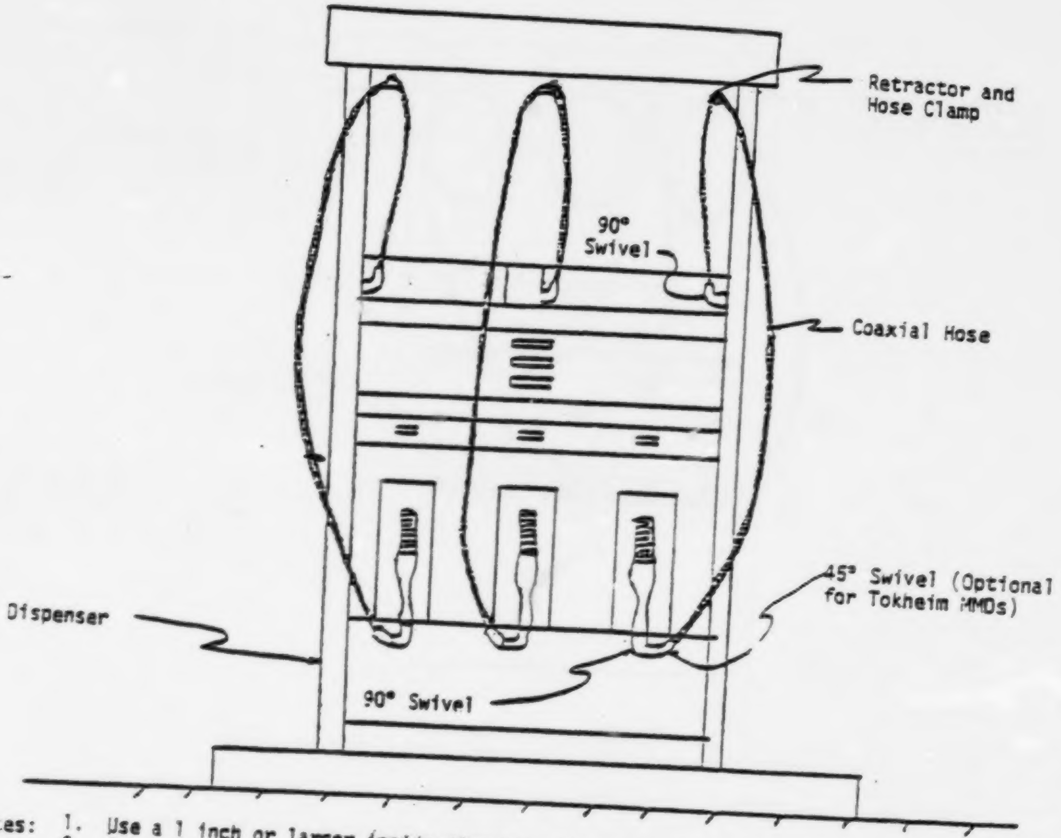
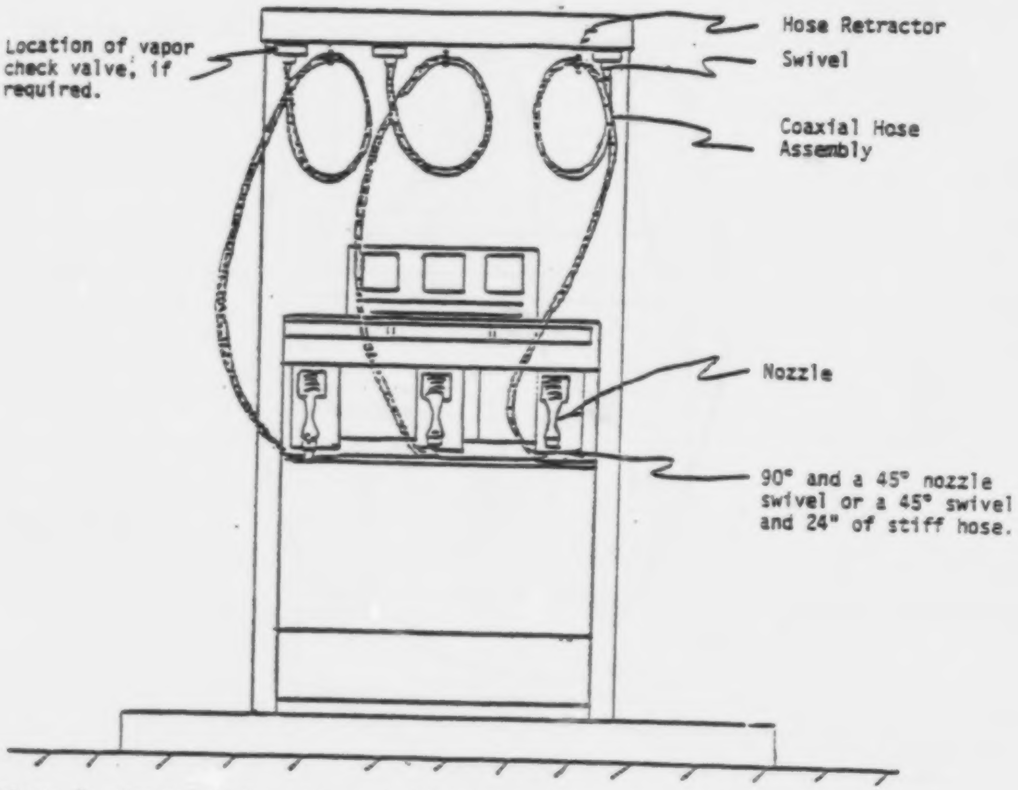
Figure B-5. Exhibit-8, High Retractor Dispenser-Coaxial Configuration For All New And Existing Installations (from Reference I-F-113)



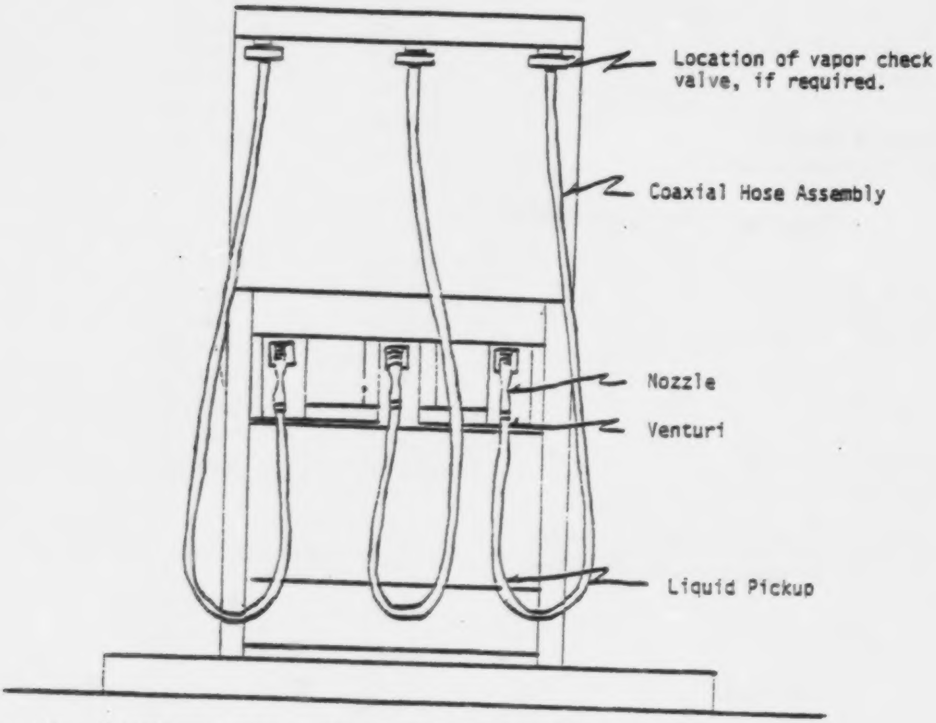
es:
1. Use a 1 inch or larger inside diameter galvanized pipe for riser.
2. A recirculation trap is not required.
3. A flow limiter is required on dispensers that have a maximum flowrate in excess of 10 gpm. A flow limiter may be required on all gasoline dispensers at the option of the local air pollution control district.
4. For dispenser islands greater than 4 feet in width, each vapor hose length, shall not be longer than the sum of one-half the dispenser island width, in feet, plus 7 feet.
5. For dispenser islands less than 4 feet, the maximum hose length is 9 feet.
6. Coaxial hose stiffeners must be included and long enough to prevent kinking or flattening of hose.
7. Retractor must retract coaxial hose to top of dispensers when not in use.
8. Tension on retractor hose clamp must not be in excess of that required to return hose to top of dispenser.
9. The Emco Wheaton Model A4000 series nozzles and the OPW 11V Model F vapor recovery nozzles are permitted only when used in conjunction with approved vapor check valves.

Figure B-6. Exhibit 9, High-Hang Hose Configuration With Retractor For All New And Existing Installations (from Reference I-F-113)


Location of vapor check valve, if required.
Hose Retractor
Swivel
Coaxial Hose Assembly
Nozzle
90° and a 45° nozzle swivel or a 45° swivel and 24" of stiff hose.

Notes:
1. Use a 1 inch or larger inside diameter galvanized pipe for riser.
2. A recirculation trap is not required.
3. A flow limiter is required on dispensers that have a maximum flowrate in excess of 10 gpm. A flow limiter may be required on all gasoline dispensers at the option of the local air pollution control district.
4. For dispensers islands greater than 4 feet in width, each vapor hose length shall not be longer than the sum of one-half the dispenser island width, in feet plus 7 1/2 feet.
5. For dispenser islands less than 4 feet, the maximum hose length is 9 1/2 feet.
6. Coaxial hose stiffeners must be included and long enough to prevent kinking or flattening of hose.
7. Retractor must retract coaxial hose to top of dispensers when not in use.
8. Tension on retractor hose clamp must not be in excess of that required to return hose to top of dispenser.
9. 90° swivel is not required if hose stiffener at nozzle is >24 inches in length.
10. The Emco Wheaton Model A4000 series nozzles and the OPW 11V Model F vapor recovery nozzles are permitted only when used in conjunction with approved vapor check valves.

Figure B-7. Exhibit 10, High-Hang Coaxial Hose Configuration With Liquid Removal System For All New And Existing Installations (from I-F-113)



Notes:
1. Use a 1 inch or larger inside diameter galvanized pipe for riser.
2. A recirculation trap is not required.
3. Hose length = 10 1/2 ft. maximum.
4. Coaxial hose stiffeners must be included and long enough to prevent kinking or flattening of hose.
5. An ARB certified liquid removal system must be installed and maintained according to manufacturer's specifications.
6. A flow limiter is required on all dispensers that have a maximum flowrate in excess of 10 gpm. A flow limiter may be required on all gasoline dispensers at the option of the local air pollution control district.
7. The Emco Wheaton Model A4000 series nozzles and the OPW 11V Model F vapor recovery nozzles are permitted only when used in conjunction with approved vapor check valves.

Table B-2. BALANCE SYSTEM DISPENSER MODIFICATION EQUIPMENT PURCHASE COST[a] ($/Nozzle)

	Cost of Component		
	LOW	HIGH	AVERAGE
EXHIBIT 4 - Twin Hose Side-Mount			
High Hose Retractor	94.00	102.50	96.08
Swivels for Nozzles	42.40	75.00	54.87
Swivels for Isl or Disp	21.50	21.50	21.50
Swivels for Retract	0.00	0.00	0.00
Flow Limiter	20.00	20.00	20.00
Hose	13.50	35.28	24.39
Disp-Hook & Handle	16.00	38.00	27.00
Total Purchase Cost	207.40	292.28	243.84
EXHIBIT 5 - Coaxial Hose Side-Mount			
High Hose Retractor	94.00	102.50	96.08
Swivels-Nozzles	40.00	58.80	49.40
Swivels-Isl or Disp	58.80	82.10	70.45
Swivels-Retract	8.08	8.08	8.08
Flow Limiter	20.00	20.00	20.00
Hose	100.00	100.00	100.00
Disp-Hook & Handle	16.00	38.00	27.00
Total Purchase Cost	336.88	409.48	371.01
EXHIBIT 6 - Twin or Coaxial Hose Dispenser-Mount (Average of twin and coaxial presented)			
High Hose Retractor	94.00	102.50	96.08
Swivels-Nozzles	42.40	75.00	54.87
Swivels-Isl or Disp	21.50	21.50	21.50
Swivels-Retract	0.00	0.00	0.00
Flow Limiter	20.00	20.00	20.00
Hose	56.75	67.64	62.20
Disp-Hook & Handle	16.00	38.00	27.00
Total Purchase Cost	250.65	324.64	281.65
EXHIBIT 7 - Twin Hose Dispenser-Mount			
High Hose Retractor	94.00	102.50	96.08
Swivels-Nozzles	42.40	75.00	54.87
Swivels-Isl or Disp	0.00	0.00	0.00
Swivels-Retract	8.08	8.08	8.08
Flow Limiter	20.00	20.00	20.00
Hose	13.50	35.28	24.39
Disp-Hook & Handle	16.00	38.00	27.00
Total Purchase Cost	193.98	278.86	230.42

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[a] See docket entries I-E-18, I-E-19, I-E-20, I-E-22, I-E-26, I-E-27, I-E-28, I-E-31, I-E-32, I-E-58, I-E-62, I-E-63, I-E-64, I-E-65, I-E-66, I-E-67, I-F-110, and I-F-111.

Table B-2. BALANCE SYSTEM DISPENSER MODIFICATION EQUIPMENT PURCHASE COST[a]
($/Nozzle)
(concluded)

EXHIBIT 8 - Coaxial High Retractor	Cost of Component		
	LOW	HIGH	AVERAGE
Overhead Hose Retractor	94.00	102.50	96.08
Swivels for Nozzles	80.00	117.60	98.80
Swivels for Isl. or Disp.	0.00	0.00	0.00
Swivels for Retractor	40.00	58.80	49.40
Flow Limiter	20.00	20.00	20.00
Hose	90.00	112.50	103.45
Liquid Removal Venturi	0.00	0.00	0.00
Dispenser Modification	38.00	55.00	46.50
	362	466.4	414.23
EXHIBIT 9 - High-Hang Hose			
Overhead Hose Retractor	85.84	100.00	92.92
Swivels for Nozzles	80.00	117.60	98.80
Swivels for Isl. or Disp.	0.00	0.00	0.00
Swivels for Retractor	40.00	58.80	49.40
Flow Limiter	20.00	20.00	20.00
Hose	95.00	118.17	108.92
Liquid Removal Venturi	0.00	0.00	0.00
Dispenser Modification	54.17	54.17	54.17
	375.01	469.32	424.21
EXHIBIT 10 - Coaxial High-Hang Hose with Liquid Removal System			
Overhead Hose Retractor	0.00	0.00	0.00
Swivels for Nozzles	40.00	58.80	49.40
Swivels for Isl. or Disp.	0.00	0.00	0.00
Swivels for Retractor	40.00	58.80	49.40
Flow Limiter	20.00	20.00	20.00
Hose	105.00	131.25	119.82
Liquid Removal Venturi	200.00	200.00	200.00
Dispenser Modification	54.17	54.17	54.17
	459.17	523.02	492.79
Average Total Purchase Cost[b]			354.75

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[b] Average cost analysis of 75 percent coaxial single dispensers (Exhibits 5 and 6) and 25 percent coaxial multiproduct dispensers (Exhibits 8 through 10).

is based on the use of all coaxial hoses and 75 percent single dispensers (average of exhibits 5 and 6) and 25 percent multiproduct dispensers (average of Exhibits 8-10). This weighted average cost was used as the purchase cost incurred when modifying a standard dispenser to a vapor recovery equipped dispenser utilizing a balance Stage II vapor recovery system.

The dispenser modification equipment list for the Hybrid system was obtained directly from the manufacturer of the hybrid system (I-E-25), and includes the Model 100 jet pump, Model CX-6 adapter, Model S swivel, Model CX hose, Model 143 control valve, and an installation kit. The total price is $435 per nozzle.

The dispenser modification equipment cost (excluding nozzles) for the Assist-1 system is the same as that for the balance system (i.e., about $355), plus the cost of a ball check valve ($16.95, I-E-23). Thus, the total unit price for dispenser modification equipment for the Assist-1 system was estimated to be $367 per nozzle.

The dispenser modification cost for the Assist-2 system was obtained directly from the manufacturer of the system (I-F-106), and includes the Hasstech vapor hose, ITT flow control valve, A.Y. McDonald impact valve, hose swivels, and Hasstech Model 1025 flame arrestor. The unit price is $205.

Tables B-3 through B-7 present the aboveground direct costs that would be incurred for each model plant. These tables include the component costs for the balance system, the Hybrid System (Healy) and the vacuum assist system (Hirt = Assist-1, Hasstech = Assist-2). Table B-8 outlines the information on nozzles and islands assumed in the cost analysis for each model plant. The data for single dispensers include the same nozzle-per-station assumptions used in the 1984 EPA analysis found in "Evaluation of Air Pollution Regulatory Strategies for Gasoline Marketing Industry," EPA-450/3-84-012a (I-A-55). The assumptions for the multiproduct dispensers (MPD's) include the installation of one 4-nozzle MPD to replace each 3-dispenser island. An uneven number of nozzles results from the 75/25 weighting of the nozzles associated with single/multiproduct dispensers.

TABLE B-3. MODEL PLANT 1 STAGE II ABOVEGROUND DIRECT COST

ABOVEGROUND COMPONENTS	UNIT COST	NUMBER OF COMPONENTS				
		BAL-I	BAL-M	HYBRID	ASSIST-1	ASSIST-2
DISPENSER COMPONENTS						
NOZZLE BALANCE (a)	197	2.50	2.50			
NOZZLE HYBRID (b)	215			2.50		
NOZZLE ASSIST-1 (c)	178				2.50	
NOZZLE ASSIST-2 (d)	124					2.50
MOD EQUIP BALANCE (e)	355	2.50	2.50			
MOD EQUIP HYBRID (f)	435			2.50		
MOD EQUIP ASSIST-1 (g)	372				2.50	
MOD EQUIP ASSIST-2 (h)	205					2.50
AUXILIARY ITEMS (i)						
ASSIST-1	3,975				1.00	
ASSIST-2	3,900					1.00
INSTALLATION						
BALANCE DISPENSER (j)	80	2.50	2.50			
HYBRID DISPENSER (k)	100			2.50		
ASSIST-1 DISPENSER (l)	45				2.50	
ASSIST-2 DISPENSER (m)	50					2.50
ASSIST-1 AUXILIARY (n)	1,400				1.00	
ASSIST-2 AUXILIARY (o)	1,200					1.00
DISPENSER PURCHASE COST		1,379	1,379	1,625	1,373	823
AUX ITEMS PURCHASE COST		0	0	0	3,975	3,900
DISP INSTALLATION COST		200	200	250	113	125
AUX INSTALLATION COST		0	0	0	1,400	1,200
DISPENSER DIRECT COST		1,579	1,579	1,875	1,486	948
AUX ITEMS DIRECT COST		0	0	0	5,375	5,100
TOTAL DIRECT COST		1,579	1,579	1,875	6,861	6,048

* Weighted average costs assuming 75 percent single dispensers and 25 percent multiproduct dispensers.

TABLE B-4. MODEL PLANT 2 STAGE II ABOVEGROUND DIRECT COST

ABOVEGROUND COMPONENTS	UNIT COST	NUMBER OF COMPONENTS				
		BAL-I	BAL-M	HYBRID	ASSIST-1	ASSIST-2
DISPENSER COMPONENTS						
NOZZLE BALANCE (a)	197	3.25	3.25			
NOZZLE HYBRID (b)	215			3.25		
NOZZLE ASSIST-1 (c)	178				3.25	
NOZZLE ASSIST-2 (d)	124					3.25
MOD EQUIP BALANCE (e)	355	3.25	3.25			
MOD EQUIP HYBRID (f)	435			3.25		
MOD EQUIP ASSIST-1 (g)	372				3.25	
MOD EQUIP ASSIST-2 (h)	205					3.25
AUXILIARY ITEMS (i)						
ASSIST-1	3,975				1.00	
ASSIST-2	3,900					1.00
INSTALLATION						
BALANCE DISPENSER (j)	80	3.25	3.25			
HYBRID DISPENSER (k)	100			3.25		
ASSIST-1 DISPENSER (l)	45				3.25	
ASSIST-2 DISPENSER (m)	50					3.25
ASSIST-1 AUXILIARY (n)	1,400				1.00	
ASSIST-2 AUXILIARY (o)	1,200					1.00
DISPENSER PURCHASE COST		1,793	1,793	2,113	1,785	1,069
AUX ITEMS PURCHASE COST		0	0	0	3,975	3,900
DISP INSTALLATION COST		260	260	325	146	163
AUX INSTALLATION COST		0	0	0	1,400	1,200
DISPENSER DIRECT COST		2,053	2,053	2,438	1,931	1,232
AUX ITEMS DIRECT COST		0	0	0	5,375	5,100
TOTAL DIRECT COST		2,053	2,053	2,438	7,306	6,332

* Weighted average costs assuming 75 percent single dispensers and 25 percent multiproduct dispensers.

TABLE B-5. MODEL PLANT 3 STAGE II ABOVEGROUND DIRECT COST

ABOVEGROUND COMPONENTS	UNIT COST	NUMBER OF COMPONENTS				
		BAL-I	BAL-M	HYBRID	ASSIST-1	ASSIST-2
DISPENSER COMPONENTS						
NOZZLE BALANCE (a)	197	6.50	6.50			
NOZZLE HYBRID (b)	215			6.50		
NOZZLE ASSIST-1 (c)	178				6.50	
NOZZLE ASSIST-2 (d)	124					6.50
MOD EQUIP BALANCE (e)	355	6.50	6.50			
MOD EQUIP HYBRID (f)	435			6.50		
MOD EQUIP ASSIST-1 (g)	372				6.50	
MOD EQUIP ASSIST-2 (h)	205					6.50
AUXILIARY ITEMS (i)						
ASSIST-1	3,975				1.00	
ASSIST-2	3,900					1.00
INSTALLATION						
BALANCE DISPENSER (j)	80	6.50	6.50			
HYBRID DISPENSER (k)	100			6.50		
ASSIST-1 DISPENSER (l)	45				6.50	
ASSIST-2 DISPENSER (m)	50					6.50
ASSIST-1 AUXILIARY (n)	1,400				1.00	
ASSIST-2 AUXILIARY (o)	1,200					1.00
DISPENSER PURCHASE COST		3,586	3,586	4,225	3,570	2,139
AUX ITEMS PURCHASE COST		0	0	0	3,975	3,900
DISP INSTALLATION COST		520	520	650	293	325
AUX INSTALLATION COST		0	0	0	1,400	1,200
DISPENSER DIRECT COST		4,106	4,106	4,875	3,863	2,464
AUX ITEMS DIRECT COST		0	0	0	5,375	5,100
TOTAL DIRECT COST		4,106	4,106	4,875	9,238	7,564

* Weighted average costs assuming 75 percent single dispensers and 25 percent multiproduct dispensers.

TABLE B-6. MODEL PLANT 4 STAGE II ABOVEGROUND DIRECT COST

ABOVEGROUND COMPONENTS	UNIT COST	NUMBER OF COMPONENTS				
		BAL-I	BAL-M	HYBRID	ASSIST-1	ASSIST-2
DISPENSER COMPONENTS						
NOZZLE BALANCE (a)	197	9.75	9.75			
NOZZLE HYBRID (b)	215			9.75		
NOZZLE ASSIST-1 (c)	178				9.75	
NOZZLE ASSIST-2 (d)	124					9.75
MOD EQUIP BALANCE (e)	355	9.75	9.75			
MOD EQUIP HYBRID (f)	435			9.75		
MOD EQUIP ASSIST-1 (g)	372				9.75	
MOD EQUIP ASSIST-2 (h)	205					9.75
AUXILIARY ITEMS (i)						
ASSIST-1	3,975				1.00	
ASSIST-2	3,900					1.00
INSTALLATION						
BALANCE DISPENSER (j)	80	9.75	9.75			
HYBRID DISPENSER (k)	100			9.75		
ASSIST-1 DISPENSER (l)	45				9.75	
ASSIST-2 DISPENSER (m)	50					9.75
ASSIST-1 AUXILIARY (n)	1,400				1.00	
ASSIST-2 AUXILIARY (o)	1,200					1.00
DISPENSER PURCHASE COST		5,380	5,380	6,338	5,355	3,208
AUX ITEMS PURCHASE COST		0	0	0	3,975	3,900
DISP INSTALLATION COST		780	780	975	439	488
AUX INSTALLATION COST		0	0	0	1,400	1,200
DISPENSER DIRECT COST		6,160	6,160	7,313	5,794	3,695
AUX ITEMS DIRECT COST		0	0	0	5,375	5,100
TOTAL DIRECT COST		6,160	6,160	7,313	11,169	8,795

* Weighted average costs assuming 75 percent single dispensers and 25 percent multiproduct dispensers.

TABLE B-7. MODEL PLANT 5 STAGE II ABOVEGROUND DIRECT COST

ABOVEGROUND COMPONENTS	UNIT COST	NUMBER OF COMPONENTS				
		BAL-I	BAL-M	HYBRID	ASSIST-1	ASSIST-2
DISPENSER COMPONENTS						
NOZZLE BALANCE (a)	197	16.25	16.25			
NOZZLE HYBRID (b)	215			16.25		
NOZZLE ASSIST-1 (c)	178				16.25	
NOZZLE ASSIST-2 (d)	124					16.25
MOD EQUIP BALANCE (e)	355	16.25	16.25			
MOD EQUIP HYBRID (f)	435			16.25		
MOD EQUIP ASSIST-1 (g)	372				16.25	
MOD EQUIP ASSIST-2 (h)	205					16.25
AUXILIARY ITEMS (i)						
ASSIST-1	3,975				1.00	
ASSIST-2	3,900					1.00
INSTALLATION						
BALANCE DISPENSER (j)	80	16.25	16.25			
HYBRID DISPENSER (k)	100			16.25		
ASSIST-1 DISPENSER (l)	45				16.25	
ASSIST-2 DISPENSER (m)	50					16.25
ASSIST-1 AUXILIARY (n)	1,400				1.00	
ASSIST-2 AUXILIARY (o)	1,200					1.00
DISPENSER PURCHASE COST		8,966	8,966	10,563	8,925	5,346
AUX ITEMS PURCHASE COST		0	0	0	3,975	3,900
DISP INSTALLATION COST		1,300	1,300	1,625	731	813
AUX INSTALLATION COST		0	0	0	1,400	1,200
DISPENSER DIRECT COST		10,266	10,266	12,188	9,657	6,159
AUX ITEMS DIRECT COST		0	0	0	5,375	5,100
TOTAL DIRECT COST		10,266	10,266	12,188	15,032	11,259

* Weighted average costs assuming 75 percent single dispensers and 25 percent multiproduct dispensers.

FOOTNOTES FOR TABLES B-3 THROUGH B-7

[a] Average cost of new nozzles certified by California for use with a balance system. Costs for new nozzles range from $196 to $198 (I-E-28, I-F-110, and I-F-111).

[b] Actual cost of a new Healy Model 200 nozzle (I-E-25).

[c] Average costs of new nozzles certified by California for use with the Hirt system. Costs of new nozzles range from $151 to $198 (I-E-28, I-F-110, and I-F-111).

[d] Actual costs of a new Husky Model HP-2 nozzle. Reference I-F-106 states that eight of these nozzles cost $992.

[e] Modification equipment includes the average cost of the high-hang retractor system, swivels, flow limiter, and hoses as certified by California (see Tables B-1 and B-2).

[f] Modification equipment includes the Model 100 jet pump, Model CX-6 adapter, Model S swivel, Model CX hose, Model 143 control valve, and an installation kit (I-E-25).

[g] Modification equipment includes the same equipment as listed for the balance system (footnote "f") plus a $16.95 ball check valve (I-E-23 and Tables B-1 and B-2).

[h] Modification equipment includes the Hasstech vapor hose, ITT flow control valve, A.Y. McDonald impact valve, hose swivels, and Hasstech Model 1025 flame arrestor (I-F-106).

[i] Auxiliary equipment includes a P/V valve, collection unit, and processing unit (I-E-35 and I-F-106).

[j] Reference I-E-46.

[k] Reference I-E-25.

[l] Reference I-E-35.

[m] Reference I-F-106 states installation for an 8-nozzle station costs $400.00.

[n] Reference I-E-35.

[o] Electrical installation costs $500 and base unit installation costs $700 (I-F-106).

Table B-8. MODEL PLANT CONFIGURATIONS[a]

Parameter	Model Plant 1	2	3	4	5
Average Monthly Throughput (gal/mo)	5,000	20,000	35,000	65,000	185,000
Throughput Range (gal/mo)	0-10,000	10,000-25,000	25,000-50,000	50,000-100,000	>100,000
No. of Islands	1	1	2	3	4
No. of Nozzles					
- Single Dispensers	2[c]	3	6	9	15[b]
- Multiproduct dispensers	4	4	8	12	20
- Weighted average[d]	2.50	3.25	6.50	9.75	16.25
No. of Dispensers	2[c]	3	6	9	12
- Single Dispensers	2[c]	3	6	9	12
- Multiproduct dispensers	1	1	2	3	5

[a] A typical island contains three single nozzle dispensers for each gasoline type (i.e., leaded, unleaded, and unleaded premium).

[b] Three islands have dual nozzle dispensers.

[c] Contains a single nozzle dispenser for leaded and unleaded only.

[d] Weighted average for existing facilities = 75 percent single dispensers and 25 percent multiproduct dispensers. (Weighted average for new facilities = 25 percent single dispensers and 75 percent multiproduct dispensers).

B.2.1.2 Nozzle Costs

The unit cost for each nozzle type shown in Tables B-3 through B-7 represents the cost of a new vapor recovery nozzle for each specific system manufacturer. The cost shown for a balance system nozzle is an average of several prices obtained from manufacturers of the approved nozzles listed in Table B-1 (i.e., Emco Wheaton, OPW, References I-E-28, I-F-110, and I-F-111). The new vapor recovery nozzles cost from $196 to $198, and thus a price of $197 for both balance-individual nozzles and balance-manifolded nozzles was used. These cost were later verified by again contacting the equipment manufacturers (I-E-65, I-E-66) and reflect the costs of the newest light-weight certified nozzles.

The unit cost shown in Tables B-3 through B-7 for the Assist-1 nozzle is an average cost of new nozzles certified by California for use with the Hirt system. Costs were obtained from the manufacturers of the nozzles used with this system (I-E-28, I-F-110, and I-F-111). The prices ranged from $157 to $198, and thus the average unit price of $178 was used.

The Assist-2 nozzle unit cost shown in Tables B-3 through B-7 is the actual cost of the Husky Model HP-2 nozzle (I-F-106).

While rebuilt nozzles are available as replacement equipment, new nozzle prices were used in the estimation of costs because information on the use and durability of rebuilt nozzles was not available to EPA when these costs were being collected.

B.2.1.3 Dispenser Installation Costs

The balance system costs were obtained from one contractor (I-E-46) who estimated that it would take 2 man-days to install all aboveground equipment at a two-island six-nozzle station. The following shows the information obtained and how the unit costs for a balance system were calculated:

2 man-days at $200/day = $400,
Profit (20%) = $ 80,
Total cost for 6-nozzle station = $480,
Unit cost for 1-nozzle station = $ 80.

The Hybrid, Assist-1, and Assist-2 dispenser installation costs, obtained directly from the manufacturers of these systems, are $100, $45, and $50 per nozzle, respectively (I-E-25, I-E-35, and I-F-106).

B.2.1.4 Auxiliary Equipment and Installation

The auxiliary items for the Assist-1 and Assist-2 systems include a pressure/vacuum (P/V) valve, blower collection unit, and processing unit. The costs for these items and their installation were obtained directly from the system manufacturers (I-E-35 and I-F-106). The costs for auxiliary items for Assist-1 and Assist-2 systems are $3,975 and $3,900, respectively, while the installation of these items costs $1,400 and $1,200, respectively.

B.2.2 Underground Costs

To estimate the costs of the underground piping systems, the layout of each model plant had to be determined. A representative equipment configuration was then determined for each model plant and, for each configuration, costs were estimated.

B.2.2.1 Station Layout and Equipment Configuration

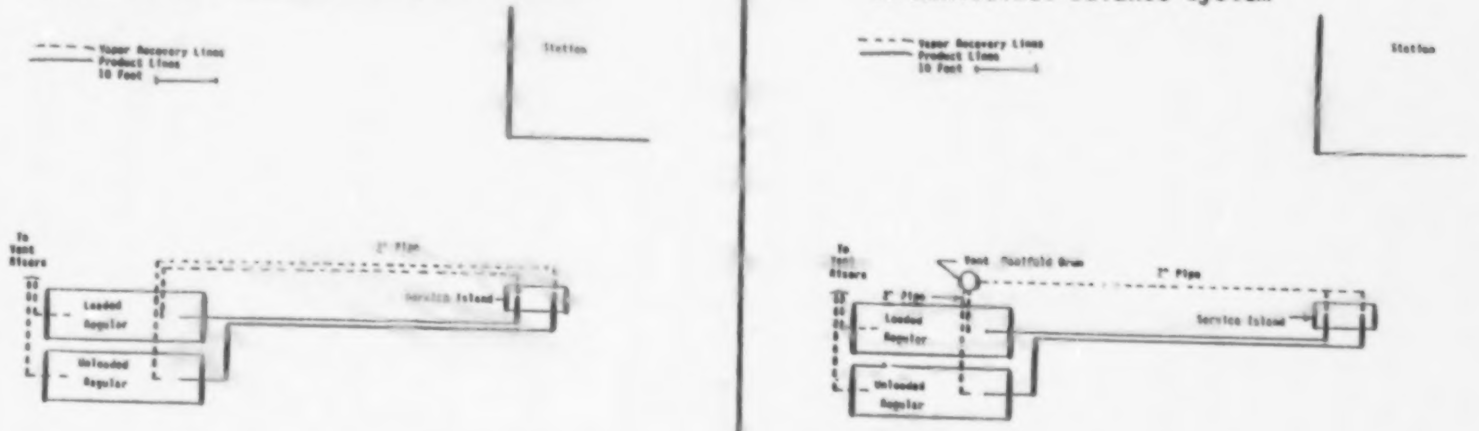
A survey of about 40 service stations was performed around the Research Triangle Park area in North Carolina. No one specific layout was a rule for a specific model plant, but general tendencies in design and average distances between islands, storage tanks, and stations were determined. The general design guidelines chosen to establish the layout of each model plant are as follows:

1. The storage tanks are approximately 50 feet away from the main service island.
2. There is approximately 24 feet between adjacent service islands and station building.
3. Vent risers were typically located on the side of the station building.

Figures B-8 through B-12 incorporate these guidelines to provide a "reasonable" service station layout for each model plant. An infinite number of layouts is possible; however, the layouts presented supply the necessary means to calculate reasonable costs for the underground piping systems.

After the model plant layouts were determined, the underground piping was designed. Several guidelines were used:

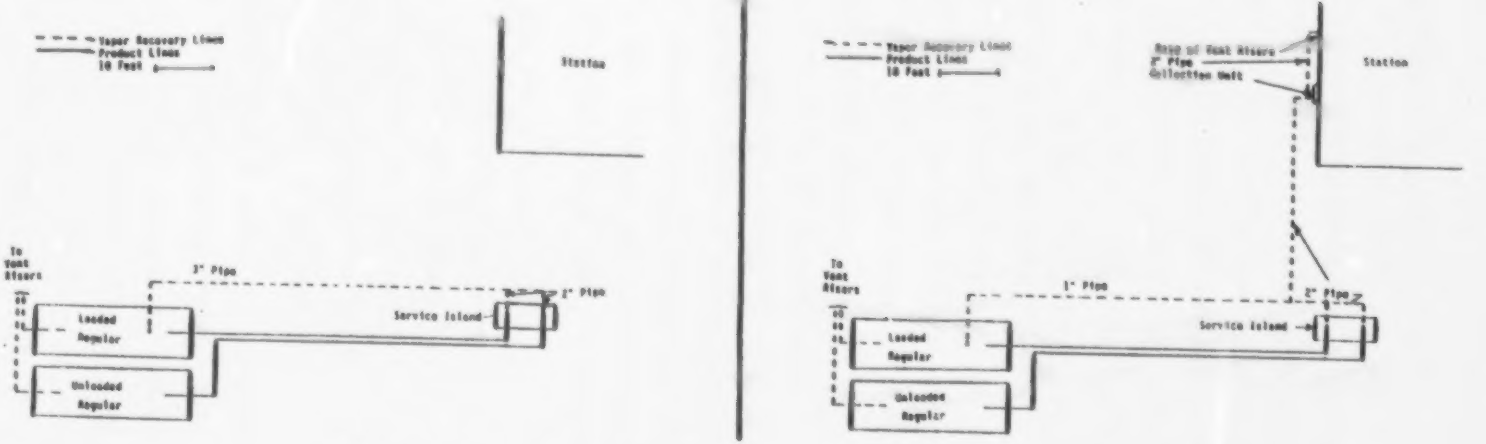
1. Vapor recovery lines are located away from product lines as much as possible to avoid disruption of the existing product lines (I-E-39).



a. Individual Balance and Hybrid Systems

b. Manifolded Balance System

Vapor Recovery Lines
Product Lines
10 Feet
Station
To Vent Risers
Loaded Regular
Unloaded Regular
2" Pipe
Service Island
Vapor Recovery Lines
Product Lines
10 Feet
Station
To Vent Risers
Vent Manifold Drum
2" Pipe
3" Pipe
Loaded Regular
Unloaded Regular
Service Island

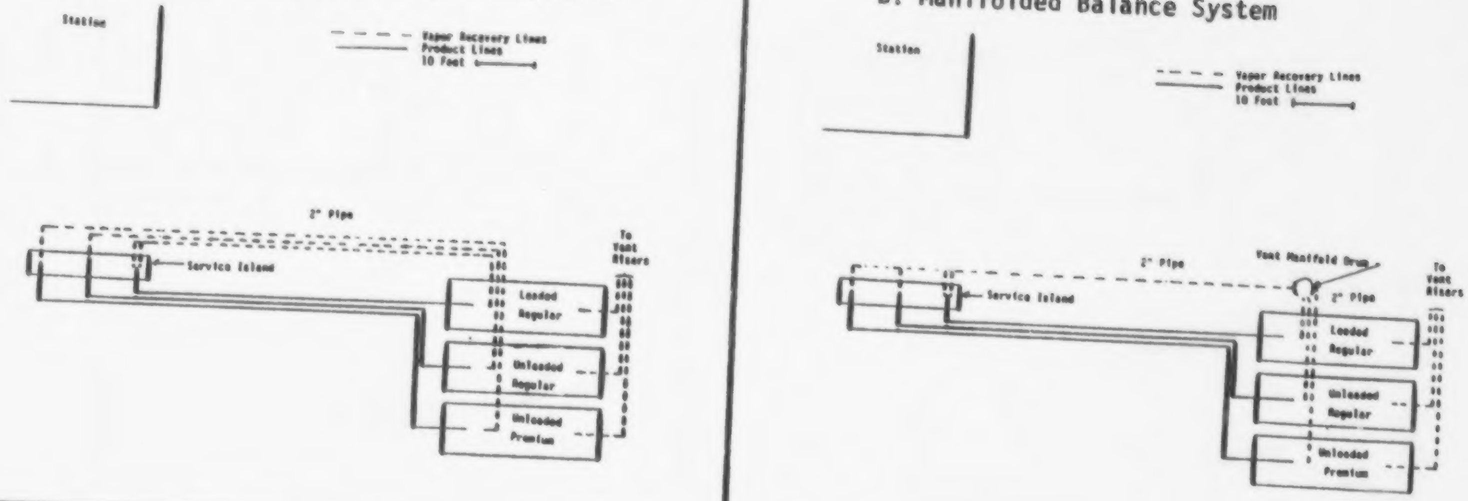


c. Assist-1 System

d. Assist-2 System

Vapor Recovery Lines
Product Lines
10 Feet
Station
To Vent Risers
3" Pipe
2" Pipe
Loaded Regular
Unloaded Regular
Service Island
Vapor Recovery Lines
Product Lines
10 Feet
Base of Vent Risers
2" Pipe
Collection Unit
Station
To Vent Risers
1" Pipe
2" Pipe
Loaded Regular
Unloaded Regular
Service Island

Figure B-8. Stage II Underground Piping Layouts for Model Plant 1



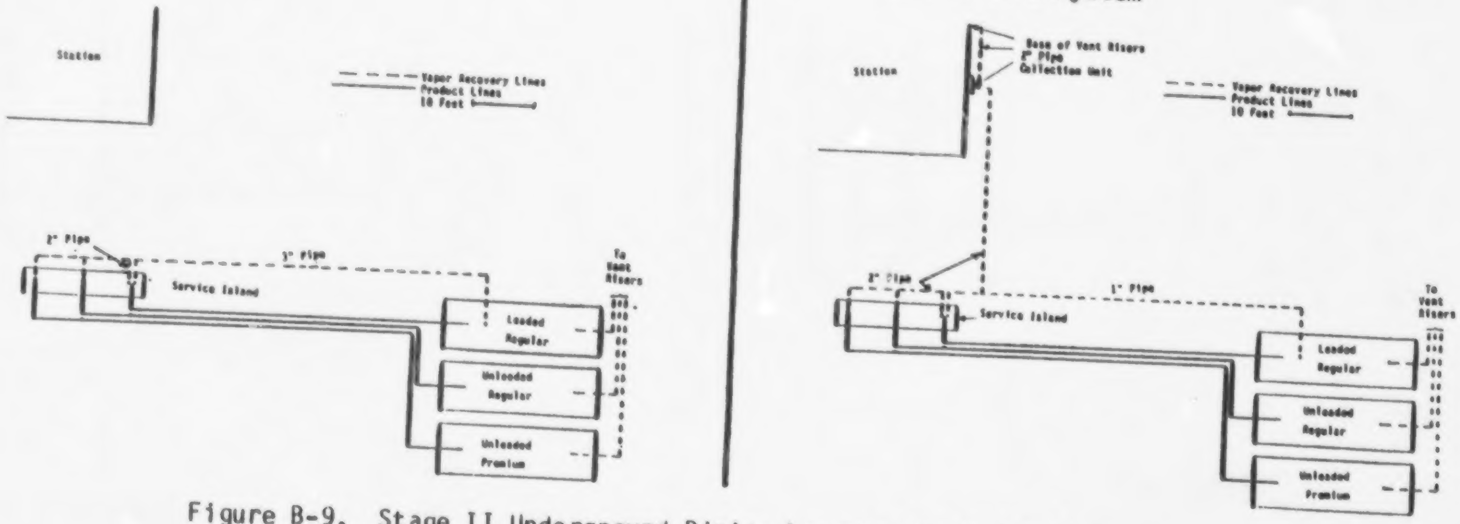
a. Individual Balance and Hybrid Systems

b. Manifolded Balance System

Station
Vapor Recovery Lines
Product Lines
10 Feet
2" Pipe
Service Island
To Vent Risers
Loaded Regular
Unloaded Regular
Unloaded Premium
Station
Vapor Recovery Lines
Product Lines
10 Feet
2" Pipe
Vent Manifold Drum
2" Pipe
Service Island
To Vent Risers
Loaded Regular
Unloaded Regular
Unloaded Premium

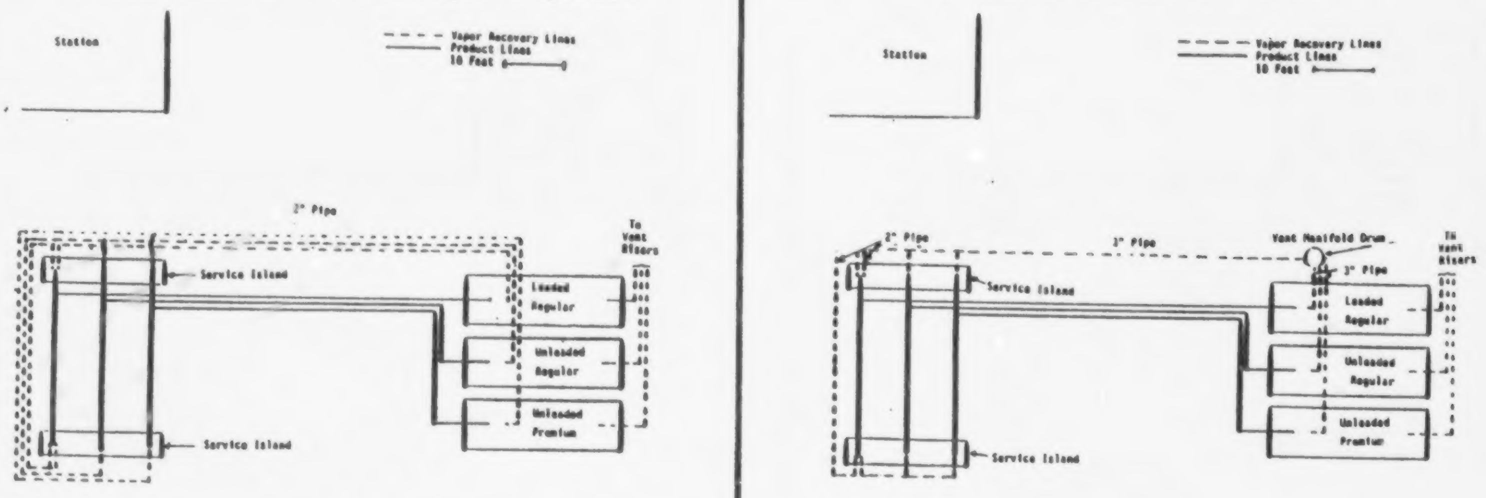
c. Assist-1 System

d. Assist-2 System



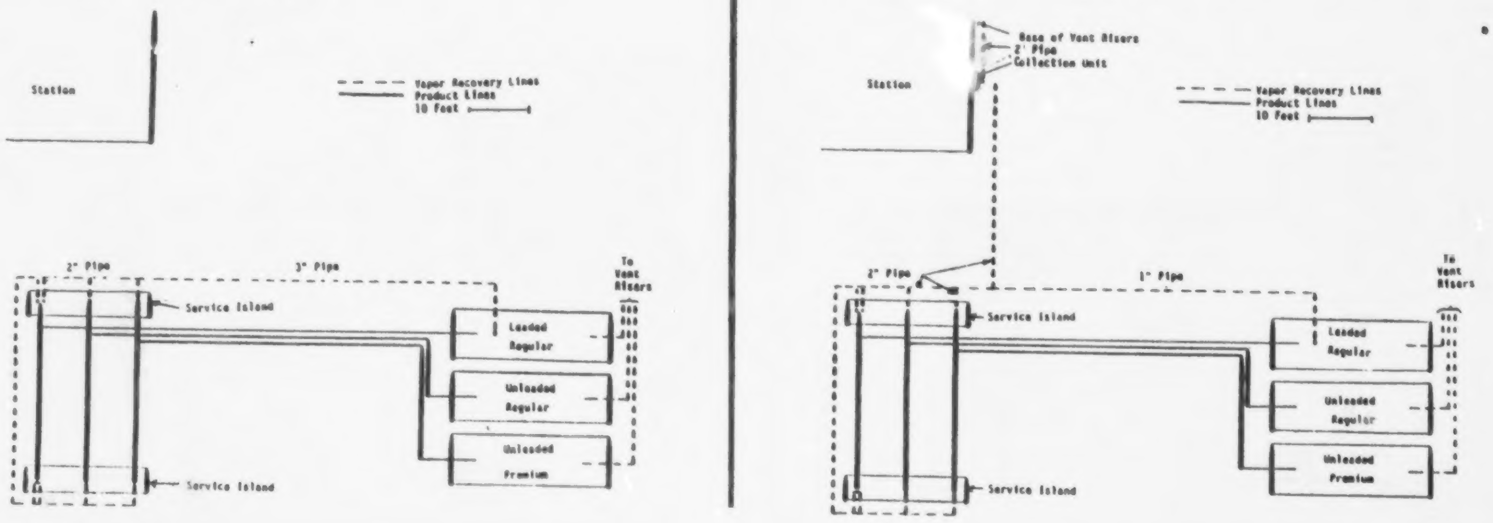
Station
Vapor Recovery Lines
Product Lines
10 Feet
2" Pipe
1" Pipe
Service Island
To Vent Risers
Loaded Regular
Unloaded Regular
Unloaded Premium
Base of Vent Risers
2" Pipe
Collection Unit
Station
Vapor Recovery Lines
Product Lines
10 Feet
2" Pipe
1" Pipe
Service Island
To Vent Risers
Loaded Regular
Unloaded Regular
Unloaded Premium

Figure B-9. Stage II Underground Piping Layouts for Model Plant 2


Station
Vapor Recovery Lines
Product Lines
10 Feet
2" Pipe
3" Pipe
To Vent Risers
Vent Manifold Drum
Service Island
Service Island
Leaded Regular
Unleaded Regular
Unleaded Premium

a. Individual Balance and Hybrid Systems

b. Manifolded Balance System


Station
Vapor Recovery Lines
Product Lines
10 Feet
Base of Vent Risers
2" Pipe
Collection Unit
2" Pipe
3" Pipe
1" Pipe
To Vent Risers
Service Island
Service Island
Leaded Regular
Unleaded Regular
Unleaded Premium

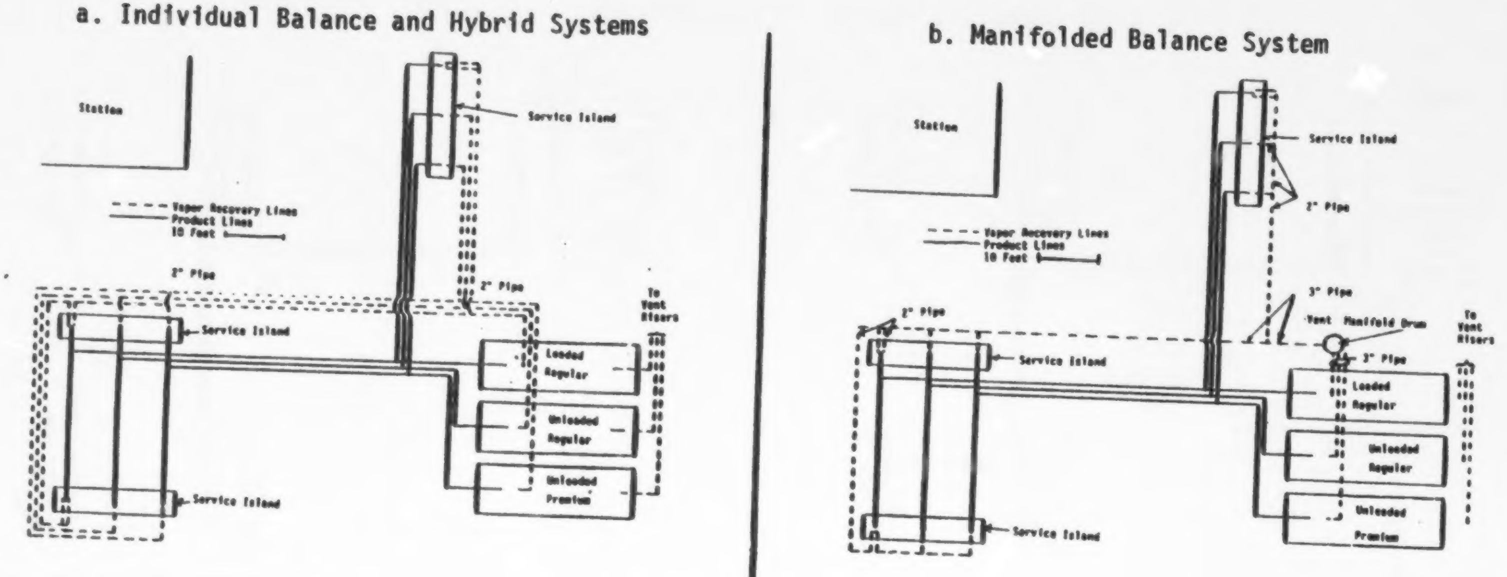
c. Assist-1 System

d. Assist-2 System

Figure B-10. Stage II Underground Piping Layouts for Model Plant 3

a. Individual Balance and Hybrid Systems

b. Manifolded Balance System


Station
Service Island
Vapor Recovery Lines
Product Lines
10 Feet
2" Pipe
3" Pipe
Vent
Manifold Drum
To Vent Risers
Loaded Regular
Unleaded Regular
Unleaded Premium

c. Assist-1 System

d. Assist-2 System

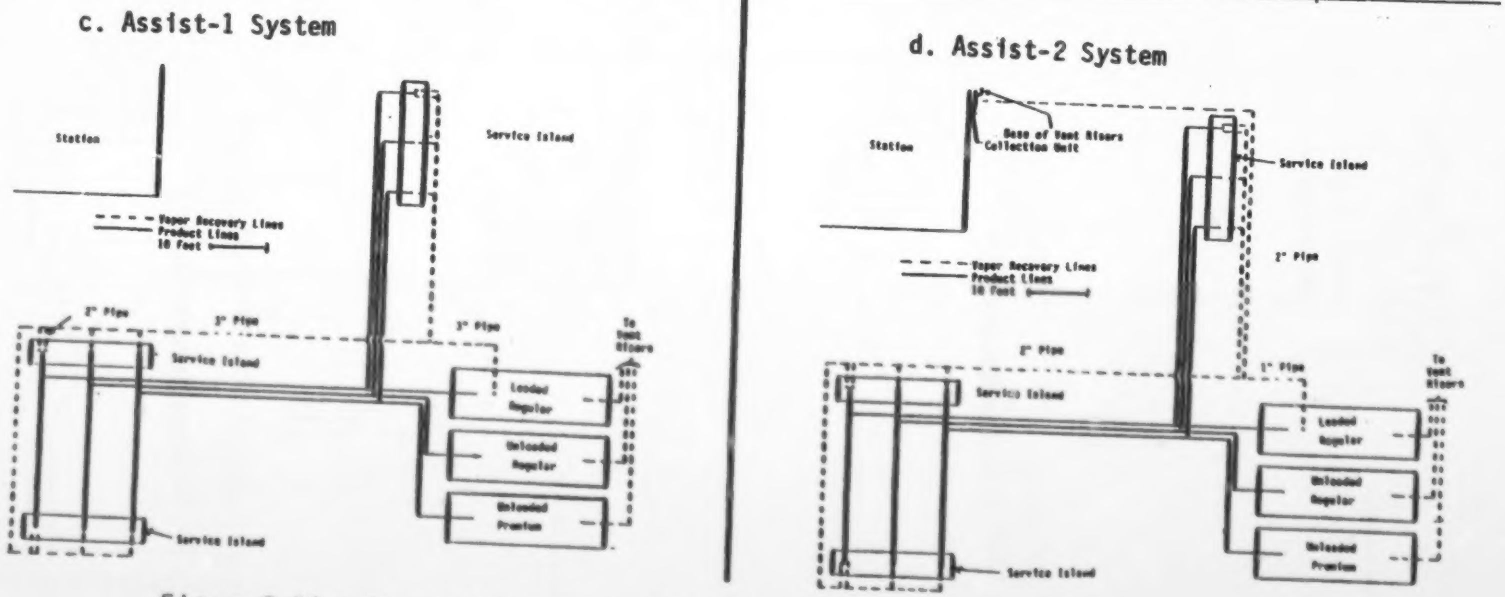
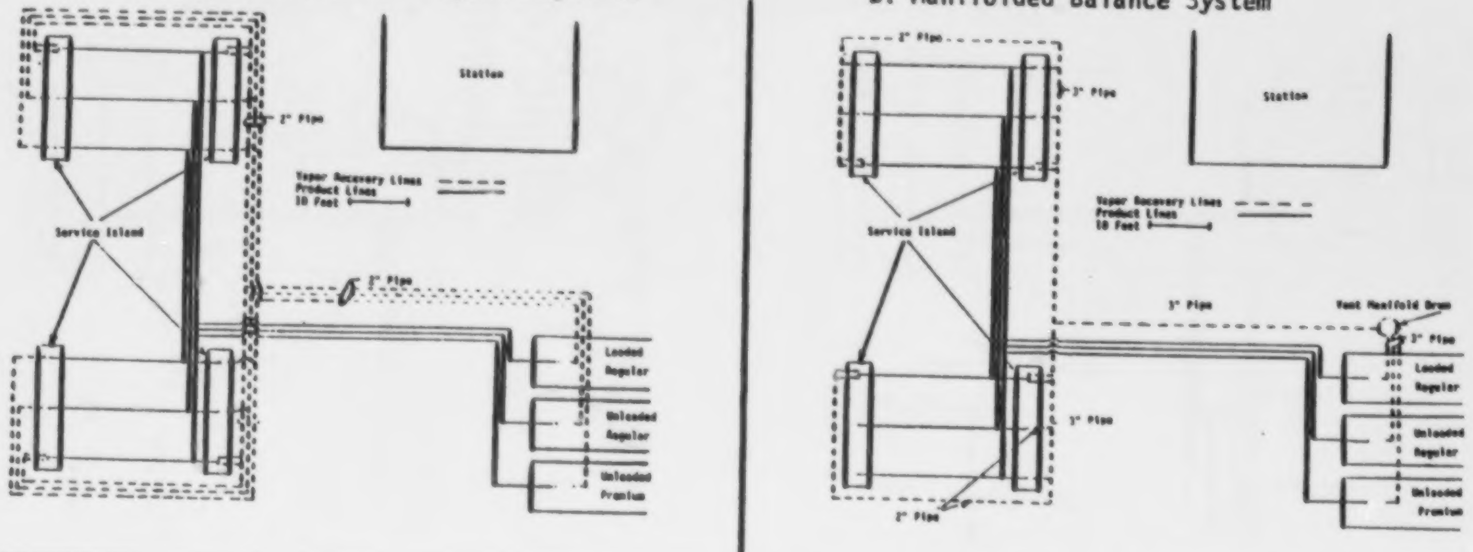

Station
Service Island
Vapor Recovery Lines
Product Lines
10 Feet
2" Pipe
3" Pipe
1" Pipe
Base of Vent Risers Collection Unit
To Vent Risers
Loaded Regular
Unleaded Regular
Unleaded Premium

Figure B-11.• Stage II Underground Piping Layouts for Model Plant 4

a. Individual Balance and Hybrid Systems

b. Manifolded Balance System


Station
2" Pipe
Vapor Recovery Lines
Product Lines
10 Feet
Service Island
2" Pipe
Loaded Regular
Unloaded Regular
Unloaded Premium
2" Pipe
3" Pipe
Station
Vapor Recovery Lines
Product Lines
10 Feet
Service Island
3" Pipe
Vent Manifold Drum
3" Pipe
Loaded Regular
3" Pipe
Unloaded Regular
Unloaded Premium
2" Pipe

c. Assist-1 System

d. Assist-2 System

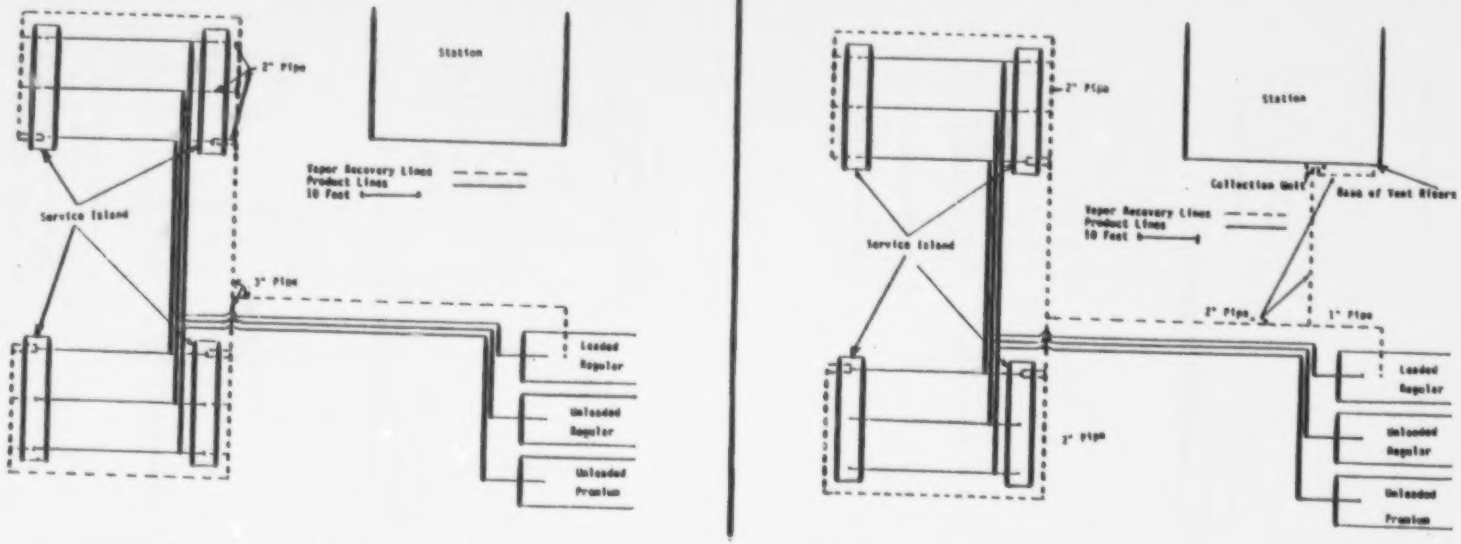

Station
2" Pipe
Vapor Recovery Lines
Product Lines
10 Feet
Service Island
3" Pipe
Loaded Regular
Unloaded Regular
Unloaded Premium
2" Pipe
Station
Collection Unit
Base of Vent Risers
Vapor Recovery Lines
Product Lines
10 Feet
Service Island
2" Pipe
1" Pipe
Loaded Regular
Unloaded Regular
Unloaded Premium
2" Pipe

Figure B-12. Stage II Underground Piping Layouts for Model Plant 5

2. One trench holds one or more vapor recovery lines.
3. Maximum pipe lengths equal 20 feet (for determination of the number of pipe couplings) (I-E-34).
4. Pipe sizes were obtained from applicable California Executive Orders (I-F-114, I-F-115, I-F-116, and I-F-117).

B.2.2.2 Underground Equipment Costs

Tables B-9 through B-13 present the underground piping costs on a model plant basis, as depicted by Figures B-8 through B-12. All unit costs for pipe (galvanized and fiberglass) were obtained from pipe vendors in the Research Triangle Park area of North Carolina (I-E-33 and I-E-34). In addition, one salesman stated that his company typically gives a 15 percent discount on all components purchased by major plumbing contractors (I-E-33). For estimating purposes, it was assumed that the companies installing the underground piping would be major contractors, so the unit costs shown have been discounted 15 percent.

A complete breakdown of parts and prices is provided to enable the costing of various piping layouts; however, the trench length of the system is the overriding cost factor (about 70 percent of the total costs of the underground system).

The cost of the vent manifold drum for the manifolded balance system is an engineering estimate; i.e., no specific quote could be obtained at this time.

Information received from contractors (I-E-40 and I-E-44) also indicated that approximately 20 percent (or fewer) of the tanks currently in use would need to be equipped with an extra bung to accept the Stage II vapor recovery line. The installed cost would be about $300/bung (I-E-52). Since all the model plants, except model plant 1, have three tanks, the cost of the bungs can be calculated as: 1 bung/tank x $300/bung x .20 x 3 tanks/model plant = $180/model plant. For model plant 1 the cost is: 1 bung/tank x $300/bung x .20 x 2 tanks/model plant = $120.

B.2.2.3 Underground Installation Costs

Installation costs can be determined for the underground equipment necessary for model plants 1 through 5 (Tables B-9 through B-13). The cost of laying piping for an individual balance system is the same as for a manifolded balance system. This is because the additional time it takes to assemble the two extra lines to the storage tanks for

TABLE B-9. MODEL PLANT 1 STAGE II UNDERGROUND DIRECT COST

UNDERGROUND COMPONENTS	UNIT COST	NUMBER OF COMPONENTS				
		BAL-I	BAL-M	HYBRID	ASSIST-1	ASSIST-2
GALVANIZED PIPE (a)						
1" PIPE (FT)	0.89	4	4	4	4	65
2" PIPE (FT)	1.88	1	1	1		
3" PIPE (FT)	3.86					
3/4" CLOSE NIPPLE	0.46	3	3	3	3	3
1" CLOSE NIPPLE	0.70	5	5	5	5	7
2" CLOSE NIPPLE	1.42	2	2	2		
3" CLOSE NIPPLE	5.41				2	
1" ELBOW	1.51	5	5	5	5	8
2" ELBOW	4.48	4	4	4		
3" ELBOW	20.11				2	
1" X 3/4" REDUCER	1.73	3	3	3	3	3
2" X 1" REDUCER	3.84	3	3	3	3	4
3" X 2" REDUCER	13.14					
2" X 1" BUSHING	2.81					1
4" X 2" BUSHING	11.09	2		2		1
4" X 3" BUSHING	11.09				1	
1" UNION	1.13					1
2" TEE	6.43					1
FIBERGLASS PIPE (b)						
2" PIPE (FT)	1.89	~~152~~	98	152	10	70
3" PIPE (FT)	2.89				73	
2" THREADED ADAPTER	7.23	5	5	5	3	5
3" THREADED ADAPTER	10.58				1	
2" ELBOW	16.41	4	2	4		4
3" ELBOW	22.82				2	
2" TEE	23.50	0	2	0		3
3" TEE	26.61		0		2	
2" COUPLING	4.68	5	2	5		3
3" COUPLING	7.23				2	
3" X 2" REDUCER	11.14		0		3	
GLUED JUNCTIONS	3.25	11	9	11	11	13
ADDITIONAL ITEMS (c)						
4" X 2" TANK BUSHING	2.61		2			
4" X 3" TANK BUSHING	2.61					
2" FLOAT CHECK VALVE	32.55		2			
VENT MANIFOLD DRUM (d)	500.00		1			
BUNGS (e)	120.00	1	1	1	1	1
LABOR COMPONENTS						
TRENCHING (FT) (f)	30.00	85	85	85	75	120
ASSEMBLY (FT) (g)	6.00	85	85	85	75	120
TOTAL PURCHASE COST		640	1,065	640	632	580
TOTAL INSTALLATION COST		3,060	3,060	3,060	2,700	4,320
TOTAL DIRECT COST		3,700	4,125	3,700	3,332	4,900

See footnotes next page.

FOOTNOTES FOR TABLE B-9

[a] Reference I-E-33.

[b] Reference I-E-34.

[c] Reference I-F-110.

[d] Unit cost is an estimated cost since no information on this was readily available.

[e] References I-E-40 and I-E-44 (see text for discussion).

[f] References I-E-41 and I-E-46 (see text for discussion).

[g] Reference I-E-46 (see text for discussion).

TABLE B-10. MODEL PLANT 2 STAGE II UNDERGROUND DIRECT COST

UNDERGROUND COMPONENTS	UNIT COST	NUMBER OF COMPONENTS				
		BAL-I	BAL-M	HYBRID	ASSIST-1	ASSIST-2
GALVANIZED PIPE (a)						
1" PIPE (FT)	0.89	5	5	5	5	66
2" PIPE (FT)	1.88	2	2	2		
3" PIPE (FT)	3.86					
3/4" CLOSE NIPPLE	0.46	3	3	3	3	3
1" CLOSE NIPPLE	0.70	7	7	7	7	9
2" CLOSE NIPPLE	1.42	3	3	3		
3" CLOSE NIPPLE	5.41				2	
1" ELBOW	1.51	7	7	7	7	10
2" ELBOW	4.48	6	6	6		
3" ELBOW	20.11				2	
1" X 3/4" REDUCER	1.73	3	3	3	3	3
2" X 1" REDUCER	3.84	3	3	3	3	4
3" X 2" REDUCER	13.14					
2" X 1" BUSHING	2.81					1
4" X 2" BUSHING	11.09	3		3		1
4" X 3" BUSHING	11.09				1	
1" UNION	1.13					1
2" TEE	6.43					1
FIBERGLASS PIPE (b)						
2" PIPE (FT)	1.89	271	138	271	13	83
3" PIPE (FT)	2.89				83	
2" THREADED ADAPTER	7.23	6	6	6	3	5
3" THREADED ADAPTER	10.58				2	
2" ELBOW	16.41	6	3	6		4
3" ELBOW	22.82				2	
2" TEE	23.50	0	2	0		3
3" TEE	26.61		0		2	
2" COUPLING	4.68	8	2	8		3
3" COUPLING	7.23				2	
3" X 2" REDUCER	11.14		0		3	
GLUED JUNCTIONS	3.25	17	12	17	13	15
ADDITIONAL ITEMS (c)						
4" X 2" TANK BUSHING	2.61		3			
4" X 3" TANK BUSHING	2.61					
2" FLOAT CHECK VALVE	32.55		3			
VENT MANIFOLD DRUM (d)	500.00		1			
BUNGS (e)	180.00	1	1	1	1	1
LABOR COMPONENTS						
TRENCHING (FT) (f)	30.00	105	105	105	85	130
ASSEMBLY (FT) (g)	6.00	105	105	105	85	130
TOTAL PURCHASE COST		1,034	1,313	1,034	789	702
TOTAL INSTALLATION COST		3,780	3,780	3,780	3,060	4,680
TOTAL DIRECT COST		4,814	5,093	4,814	3,849	5,382

Footnotes are the same as those for Table B-9.

TABLE B-11. MODEL PLANT 3 STAGE II UNDERGROUND DIRECT COST

UNDERGROUND COMPONENTS	UNIT COST	NUMBER OF COMPONENTS				
		BAL-I	BAL-M	HYBRID	ASSIST-1	ASSIST-2
GALVANIZED PIPE (a)						
1" PIPE (FT)	0.89	10	10	10	10	71
2" PIPE (FT)	1.88	2		2		
3" PIPE (FT)	3.86		2			
3/4" CLOSE NIPPLE	0.46	7	7	7	7	7
1" CLOSE NIPPLE	0.70	13	13	13	13	15
2" CLOSE NIPPLE	1.42	3		3		
3" CLOSE NIPPLE	5.41		6		2	
1" ELBOW	1.51	13	13	13	13	16
2" ELBOW	4.48	6		6		
3" ELBOW	20.11		6		2	
1" X 3/4" REDUCER	1.73	7	7	7	7	7
2" X 1" REDUCER	3.84	7	7	7	7	8
3" X 2" REDUCER	13.14		3			
2" X 1" BUSHING	2.81					1
4" X 2" BUSHING	11.09	3		3		1
4" X 3" BUSHING	11.09				1	
1" UNION	1.13					1
2" TEE	6.43					1
FIBERGLASS PIPE (b)						
2" PIPE (FT)	1.89	476	86	476	26	156
3" PIPE (FT)	2.89		125		143	
2" THREADED ADAPTER	7.23	10	10	10	7	9
3" THREADED ADAPTER	10.58		3		1	
2" ELBOW	16.41	16	2	16		6
3" ELBOW	22.82		2		4	
2" TEE	23.50	3	2	3		7
3" TEE	26.61		3		6	
2" COUPLING	4.68	9	1	9		4
3" COUPLING	7.23		2		3	
3" X 2" REDUCER	11.14		4		7	
GLUED JUNCTIONS	3.25	34	26	34	26	24
ADDITIONAL ITEMS (c)						
4" X 2" TANK BUSHING	2.61					
4" X 3" TANK BUSHING	2.61		3			
2" FLOAT CHECK VALVE	32.55		3			
VENT MANIFOLD DRUM (d)	500.00		1			
BUNGS (e)	180.00	1	1	1	1	1
LABOR COMPONENTS						
TRENCHING (FT) (f)	30.00	165	165	165	140	185
ASSEMBLY (FT) (g)	6.00	165	165	165	140	185
TOTAL PURCHASE COST		1,779	2,053	1,779	1,253	1,046
TOTAL INSTALLATION COST		5,940	5,940	5,940	5,040	6,660
TOTAL DIRECT COST		7,719	7,993	7,719	6,293	7,706

Footnotes are the same as those for Table B-9.

TABLE B-12. MODEL PLANT 4 STAGE II UNDERGROUND DIRECT COST

UNDERGROUND COMPONENTS	UNIT COST	NUMBER OF COMPONENTS				
		BAL-I	BAL-M	HYBRID	ASSIST-1	ASSIST-2
GALVANIZED PIPE (a)						
1" PIPE (FT)	0.89	15	15	15	15	33
2" PIPE (FT)	1.88	2		2		
3" PIPE (FT)	3.86		2			
3/4" CLOSE NIPPLE	0.46	10	10	10	10	10
1" CLOSE NIPPLE	0.70	20	20	20	20	22
2" CLOSE NIPPLE	1.42	3		3		
3" CLOSE NIPPLE	5.41		6		2	
1" ELBOW	1.51	20	20	20	20	23
2" ELBOW	4.48	6		6		
3" ELBOW	20.11		6		2	
1" X 3/4" REDUCER	1.73	10	12	12	12	12
2" X 1" REDUCER	3.84	10	12	12	12	13
3" X 2" REDUCER	13.14		3			
2" X 1" BUSHING	2.81					1
4" X 2" BUSHING	11.09	3		3		1
4" X 3" BUSHING	11.09				1	
1" UNION	1.13					1
2" TEE	6.43					1
FIBERGLASS PIPE (b)						
2" PIPE (FT)	1.89	579	139	579	39	304
3" PIPE (FT)	2.89		125		183	
2" THREADED ADAPTER	7.23	13	13	13	10	12
3" THREADED ADAPTER	10.58		3		1	
2" ELBOW	16.41	22	3	22		7
3" ELBOW	22.82		2		5	
2" TEE	23.50	6	5	6		10
3" TEE	26.61		4		9	
2" COUPLING	4.68	11	2	11		8
3" COUPLING	7.23		2		4	
3" X 2" REDUCER	11.14		5		10	
GLUED JUNCTIONS	3.25	48	35	48	37	36
ADDITIONAL ITEMS (c)						
4" X 2" TANK BUSHING	2.61					
4" X 3" TANK BUSHING	2.61		3			
2" FLOAT CHECK VALVE	32.55		3			
VENT MANIFOLD DRUM (d)	500.00		1			
BUNGS (e)	100.00	1	1	1	1	1
LABOR COMPONENTS						
TRENCHING (FT) (f)	30.00	205	205	205	180	240
ASSEMBLY (FT) (g)	6.00	205	205	205	180	240
TOTAL PURCHASE COST		2,259	2,370	2,272	1,659	1,511
TOTAL INSTALLATION COST		7,380	7,380	7,380	6,480	8,640
TOTAL DIRECT COST		9,639	9,750	9,652	8,139	10,151

Footnotes are the same as those for Table B-9.

TABLE B-13. MODEL PLANT 5 STAGE II UNDERGROUND DIRECT COST

UNDERGROUND COMPONENTS	UNIT COST	NUMBER OF COMPONENTS				
		BAL-I	BAL-M	HYBRID	ASSIST-1	ASSIST-2
GALVANIZED PIPE (a)						
1" PIPE (FT)	0.89	24	24	24	24	44
2" PIPE (FT)	1.88	2		2		
3" PIPE (FT)	3.86		2			
3/4" CLOSE NIPPLE	0.46	16	16	16	16	
1" CLOSE NIPPLE	0.70	33	33	33	33	16
2" CLOSE NIPPLE	1.42	3		3		35
3" CLOSE NIPPLE	5.41		6		2	
1" ELBOW	1.51	33	33	33	33	36
2" ELBOW	4.48	6		6		
3" ELBOW	20.11		6		2	
1" X 3/4" REDUCER	1.73	16	16	16	16	16
2" X 1" REDUCER	3.34	16	16	16	16	17
3" X 2" REDUCER	13.14		3			
2" X 1" BUSHING	2.81					1
4" X 2" BUSHING	11.09	3		3		1
4" X 3" BUSHING	11.09				1	
1" UNION	1.13					1
2" TEE	6.43					1
FIBERGLASS PIPE (b)						
2" PIPE (FT)	1.89	797	185	797	65	331
3" PIPE (FT)	2.89		171		249	
2" THREADED ADAPTER	7.23	19	19	19	16	18
3" THREADED ADAPTER	10.58		3		1	
2" ELBOW	16.41	32	6	32		8
3" ELBOW	22.82		2		7	
2" TEE	23.50	12	6	12		16
3" TEE	26.61		9		15	
2" COUPLING	4.68	12	2	12		6
3" COUPLING	7.23		3		5	
3" X 2" REDUCER	11.14		10		16	
GLUED JUNCTIONS	3.25	72	57	72	60	48
ADDITIONAL ITEMS (c)						
4" X 2" TANK BUSHING	2.61					
4" X 3" TANK BUSHING	2.61		3			
2" FLOAT CHECK VALVE	32.55		3			
VENT MANIFOLD DRUM (d)	500.00		1			
BUNGS (e)	100.00	1	1	1	1	1
LABOR COMPONENTS						
TRENCHING (FT) (f)	30.00	265	265	265	245	280
ASSEMBLY (FT) (g)	6.00	265	265	265	245	280
TOTAL PURCHASE COST		3,180	3,041	3,180	2,381	1,874
TOTAL INSTALLATION COST		9,540	9,540	9,540	8,820	10,080
TOTAL DIRECT COST		12,720	12,581	12,720	11,201	11,954

Footnotes are the same as those for Table B-9.

the individual balance system (three lines from island to underground tank as opposed to one line for the manifolded system) is assumed equivalent to the additional time required to plumb the service islands when using the manifolded balance system (exact pipe lengths, sloping, additional pipe joints, etc.).

The physical characteristics of the trench for both the manifolded and individual balance systems are basically the same; therefore, the cost of trenching ($/ft) is the same for all systems.

Only two contractors provided the information necessary to determine the cost of installation for the underground piping (I-E-41 and I-E-46). All of those questioned, except one, said that a specific layout was needed before an estimate could be determined; the one exception said that he used a factor of $25 per foot of trench to estimate the cost of trenching (I-E-41).

Due to the time involved in preparing an estimate, only one contractor agreed to provide EPA with an approximate installation cost (I-E-46). The following is an estimate for installing the piping for model plant 3.

Day 1:	Dig Trench		$1,600
	4 man-days at	$200/day	
	1 backhoe-day at	$400/day	
	1 truck-day at	$400/day	
Days 2 & 3:	Lay Pipe		$ 800
	4 man-days at	$200/day	
	Modify Dispensers		$ 800*
	4 man-days at	$200/day	
Day 4:	Fill Trench and Pour Concrete		$1,750
	4 man-days at	$200/day	
	1 truck-day at	$400/day	
	pea gravel - 13 tons at $10/ton		
	concrete - 6 yds at $70/yd		
Day 5:	Lay Asphalt and Clean Up		$1,350
	3 man-days at	$200/day	
	1 truck-day at	$400/day	
	0.5 roller-day at	$400/day	
	asphalt - 5 tons at $30/ton		

Profit: 20-25 percent of total = 22.5%
Trench Length: 165 feet
Trenching = (1600 + 1750 + 1350)(1.225) = $5760/165 ft = $35/ft
Assembly = (800)(1.225) = $980/165 ft = $6/ft

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*Not included in total.

The trenching cost estimate was calculated by averaging the above $35/ft and $25/ft value, previously discussed. The cost of pipe assembly was used as shown since $200/day for a pipefitter seemed reasonable. These figures were then combined with the model plant trench lengths (feet) to obtain the installation costs presented in Tables B-9 through B-13.

B.2.3 Summary of Capital Costs

The total capital cost of a control system is the sum of direct costs, indirect costs, and contingency costs. Direct costs include purchased equipment costs (i.e., control devices, auxiliary equipment, instrumentation and controls, and freight and taxes) and installation costs (i.e., foundation and supports, erection and handling, electrical, piping and insulation). Indirect costs consist of in-house engineering design and supervision costs, architect and engineering contractor expenses, contractor fees, construction fees, and preliminary testing costs. All indirect costs have been included in the installation costs, and freight and taxes were assumed to be included in the total purchased equipment costs obtained from control system vendors. Contingency costs include such fees as penalties incurred for failure to meet completion dates set out in performance specifications. Due to the nature of this analysis, contingency costs are not appropriate.

Table B-14 presents the direct cost summary for the five Stage II systems applied to the five model plants. This table summarizes the costs shown in Tables B-2 through B-7 and B-9 through B-13. As can be seen, the use of a single cost basis for a balance system and the use of a single cost basis for an assist system should not bias subsequent cost evaluation because the cost differences between individual and manifolded balance systems and between Assist-1 and Assist-2 systems are very small. In addition, the future installation ratio of these systems is not known.

B.2.4. Annual Costs and Cost Effectiveness

Table B-15 presents an annualized cost breakdown for the model plants. As was the case when determining capital costs, several assumptions had to be made. The following points should be noted in connection with Table B-15.

TABLE B-14. STAGE II DIRECT COST SUMMARY

COMPONENT	COST OF COMPONENT				
	BAL-I	BAL-M	HYBRID	ASSIST-1	ASSIST-2
MODEL PLANT 1					
DISPENSER PURCHASE COST	1,368	1,368	1,625	1,361	823
AUXILIARY PURCHASE COST	0	0	0	3,975	3,900
PIPING PURCHASE COST	640	1,065	640	632	580
TOTAL PURCHASE COST	2,010	2,430	2,260	5,970	5,300
INSTALLATION COST	3,260	3,260	3,310	4,210	5,650
TOTAL DIRECT COST	5,270	5,690	5,570	10,180	10,950
MODEL PLANT 2					
DISPENSER PURCHASE COST	1,780	1,780	2,110	1,770	1,070
AUXILIARY PURCHASE COST	0	0	0	3,975	3,900
PIPING PURCHASE COST	1,034	1,313	1,034	789	702
TOTAL PURCHASE COST	2,810	3,090	3,140	6,530	5,670
INSTALLATION COST	4,040	4,040	4,110	4,610	6,040
TOTAL DIRECT COST	6,850	7,130	7,250	11,140	11,710
MODEL PLANT 3					
DISPENSER PURCHASE COST	3,560	3,560	4,230	3,540	2,140
AUXILIARY PURCHASE COST	0	0	0	3,975	3,900
PIPING PURCHASE COST	1,780	2,050	1,780	1,250	1,050
TOTAL PURCHASE COST	5,340	5,610	6,010	8,770	7,090
INSTALLATION COST	6,460	6,460	6,590	6,730	8,190
TOTAL DIRECT COST	11,800	12,070	12,600	15,500	15,280
MODEL PLANT 4					
DISPENSER PURCHASE COST	5,330	5,330	6,340	5,310	3,210
AUXILIARY PURCHASE COST	0	0	0	3,975	3,900
PIPING PURCHASE COST	2,260	2,370	2,270	1,660	1,510
TOTAL PURCHASE COST	7,590	7,700	8,610	10,950	8,620
INSTALLATION COST	8,160	8,160	8,360	8,320	10,330
TOTAL DIRECT COST	15,750	15,860	16,970	19,270	18,950
MODEL PLANT 5					
DISPENSER PURCHASE COST	8,890	8,890	10,560	8,850	5,350
AUXILIARY PURCHASE COST	0	0	0	3,975	3,900
PIPING PURCHASE COST	3,180	3,040	3,180	2,380	1,870
TOTAL PURCHASE COST	12,070	11,930	13,740	15,210	11,120
INSTALLATION COST	10,840	10,840	11,170	10,950	12,090
TOTAL DIRECT COST	22,910	22,770	24,910	26,160	23,210

TABLE B-15. STAGE II ANNUAL COST SUMMARY

COMPONENT/SYSTEM (a)	BAL-I	BAL-M	HYBRID	ASSIST-1	ASSIST-2
CAPITAL RECOVERY COST (b)					
MODEL PLANT 1	677	722	735	1,630	1,640
MODEL PLANT 2	881	910	960	1,770	1,740
MODEL PLANT 3	1,560	1,590	1,710	2,380	2,220
MODEL PLANT 4	2,150	2,160	2,370	2,930	2,700
MODEL PLANT 5	3,230	3,210	3,600	3,960	3,350
MAINTENANCE COST (c)					
MODEL PLANT 1	475	475	497	465	406
MODEL PLANT 2	617	617	646	575	498
MODEL PLANT 3	1,234	1,234	1,292	1,050	897
MODEL PLANT 4	1,852	1,852	1,938	1,525	1,295
MODEL PLANT 5	3,086	3,086	3,230	2,475	2,091
INSPECTION COST (d)					
MODEL PLANT 1	0	0	0	0	0
MODEL PLANT 2	0	0	0	0	0
MODEL PLANT 3	0	0	0	0	0
MODEL PLANT 4	0	0	0	0	0
MODEL PLANT 5	0	0	0	0	0
OTHER INDIRECT COSTS (e)					
MODEL PLANT 1	211	228	223	407	438
MODEL PLANT 2	274	285	290	446	468
MODEL PLANT 3	472	483	504	620	611
MODEL PLANT 4	630	635	679	771	758
MODEL PLANT 5	916	911	996	1,046	928
RECOVERY CREDITS (f)					
MODEL PLANT 1	129	129	129	65	65
MODEL PLANT 2	518	518	518	259	259
MODEL PLANT 3	906	906	906	453	453
MODEL PLANT 4	1,683	1,683	1,683	841	841
MODEL PLANT 5	4,790	4,790	4,790	2,395	2,395
ADDITIONAL CREDITS (g)					
MODEL PLANT 1	0	0	0	0	0
MODEL PLANT 2	0	0	0	0	0
MODEL PLANT 3	0	0	0	0	0
MODEL PLANT 4	0	0	0	0	0
MODEL PLANT 5	0	0	0	0	0
TOTAL ANNUALIZED COST					
MODEL PLANT 1	1,230	1,300	1,330	2,440	2,420
MODEL PLANT 2	1,250	1,290	1,380	2,530	2,450
MODEL PLANT 3	2,360	2,400	2,600	3,600	3,270
MODEL PLANT 4	2,950	2,960	3,300	4,380	3,910
MODEL PLANT 5	2,440	2,420	3,040	5,090	3,970

See next page for footnotes.

FOOTNOTES FOR TABLE B-15

[a] Bal-I = Balance-Individual, Bal-M = Balance-Manifolded, Assist-1 = Hirt; Assist-2 = Hasstech; Hybrid = Healy.

[b] Capital Recovery Cost = (Capital Cost) $\dfrac{i\,(1 + i)^a}{(1 + i)^a - 1}$

where: i = interest rate (10 percent)
a = equipment life (8 years for dispenser and auxiliary equipment; 35 years for underground piping system)

[c] 1. Nozzle Maintenance - All Systems.
Replace nozzle every 2 years with new nozzle (same lifetime as standard nozzle); therefore, annual cost equals half the incremental cost between standard nozzle ($50) and vapor-recovery nozzle (see Table B-3 for costs). For multiproduct dispensers, the nozzles are assumed to last twice as long; therefore, maintenance costs are half ($25).

2. Hose Maintenance - All Systems.
Replace vapor hose every 2 years (same lifetime as liquid hose on standard dispenser); therefore, annual cost equals half the incremental cost between standard liquid hose ($24.39) and coaxial liquid/vapor recovery hose system ($110.73 from Exhibits 8-10, Table B-2).

3. Boot/Faceplate Assembly Maintenance - Balance Systems.
Replace boot/faceplate assembly three times per year; parts cost $19 per replacement and it takes 20 minutes per replacement at $25 per hour.

4. Boot/Faceplate Assembly Maintenance - Assist Systems.
Replace boot/faceplate assembly two times per year; parts cost $15 per replacement and it takes 20 minutes per replacement at $25 per hour.

5. Boot/Faceplate Assembly Maintenance - Hybrid Systems.
Replace boot/faceplate assembly two times per year; parts cost $33 per replacement and it takes 20 minutes per replacement at $25 per hour.

6. Processing Unit Maintenance - Assist Systems.
Maintenance performed once a year by a qualified professional at a cost of $100 per visit.

[d] This expense is included in the government enforcement costs, and thus, it is not attributable to the model plant annual cost.

[e] Value includes property tax (1%), insurance (1%), and administration (2%), equalling 4 percent of the total capital cost.

FOOTNOTES FOR TABLE B-15
(concluded)

[f] Stage II recovery credit calculations:

Balance and Hybrid

Emission factors: Displacement = 1,552 mg/liter
Emptying loss = 120 mg/liter

Assuming 95% recovery of both displacement and emptying losses, recovery factor = (0.95)[(1,552 + 120)mg/liter] = 1,588 mg/liter.

Example of recovery credit:

$$1{,}588 \text{ mg/liter} \times 75{,}700^{*} \frac{\text{liters}}{\text{mo.}} \times \frac{\text{kg}}{10^6\text{mg}} \times \frac{\text{liter}}{0.67\text{kg}} \times \frac{12 \text{ mo.}}{\text{yr}} \times \$0.24/\text{liter}$$

$$= \$518/\text{year}.$$

Assist 1 & 2

Same emission factors as above.

Assuming 50% recovery of balance system losses, recovery factor = (0.50)(0.95)(1,552 mg/liter + 120 mg/liter) = 794 mg/liter.

Example of recovery credit:

$$794 \text{ mg/liter} \times 75{,}700^{*} \frac{\text{liters}}{\text{mo.}} \times \frac{\text{kg}}{10^6\text{mg}} \times \frac{\text{liter}}{0.67\text{kg}} \times \frac{12 \text{ mo.}}{\text{yr}} \times \$0.24/\text{liter}$$

$$= \$259/\text{year}.$$

Throughout this analysis, the Model Plant 1 throughput used was 5,000 gallons per month to allow a comparison with the July 1984 analysis. However, the new analysis uses recovery credits based on Model Plant 1a (2,000 gallons per month) and Model Plant 1b (6,000 gallons per month) when calculating nationwide or nonattainment area cost impacts.

[g] No additional credits taken. These could include investment tax credits or energy conservation tax credits.

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*Throughput for model plant 2.

1. Discussions with dispenser equipment vendors and the manufacturers of the two assist systems indicated that the additional dispenser equipment needed for Stage II (retractors, flow limiters, hanger kits) and the processing unit equipment will last a minimum of 5 years and should last about 10 years; 8 years was assumed for capital recovery calculation purposes (I-D-45, I-E-22, I-E-23, and I-E-25).
2. Several vendors of fiberglass piping, used quite often for vapor recovery piping in California, were contacted about the expected life of fiberglass pipe used in underground situations. All vendors contacted, except one, indicated that there was no reason why the pipe should ever need replacing (I-E-37 and I-E-38). One indicated that it would last at least 30 years (I-E-38). For purposes of this analysis, the underground piping lifetime for fiberglass pipe was estimated to be 35 years.
3. Additional credits that could be included in the calculation of "Total Annualized Cost" are, for example, investment tax credits or energy conservation tax credits. However, these are not included in this analysis.
4. Rebuilt nozzles were not included in the maintenance scenario due to insufficient data on their use at this time.
5. Currently, the annualized costs do not include enforcement costs. These costs are calculated separately and on a nationwide basis, and are included in the regulatory strategy analysis.
6. The assumptions shown in the Table B-15 footnotes were made to calculate maintenance costs. These assumptions are based on conversations with vendors of Stage II equipment (I-E-20, I-E-22, I-E-24, I-E-26, I-E-27, and I-E-29).
7. Recovery credits are calculated as shown in footnote (f) of Table B-15, using a displacement emission factor of 1,552 mg/liter and an emptying loss emission factor of 120 mg/liter. Also, the cost credit for a liter of gasoline is based on $0.24/liter gasoline ($0.91/gallon).

For balance and hybrid systems, a 95 percent recovery of both displacement and emptying losses was assumed, while for the assist systems a 50 percent recovery of balance system displacement and emptying losses was assumed. These are theoretical efficiencies used for the purpose of determining per-facility costs. For the regulatory analyses, actual in-use efficiencies were used to calculate recovery credits.

B.3 SUMMARY

Detailed costs were obtained for the five basic Stage II vapor recovery systems. The costs for the two balance systems and the costs for the two assist systems compared favorably enough that a single cost could be used for either balance system and for either assist system. The average cost of the two assist systems was taken to represent a generic cost for the assist system, since the future installation ratio of Assist-1 to Assist-2 systems is not known. Table B-16 presents the generic capital cost summary for each Stage II system type on a model plant basis. These costs are used to compute generic annualized costs on a model plant basis, as shown in Table B-17.

Information gathered also indicated that discounts on nozzles and modification equipment of approximately 30 percent are available to large volume buyers (I-E-18, I-E-24, I-E-26, and I-E-27). Table B-18 shows the generic Stage II capital cost summary with this 30 percent discount included. Table B-18 is used to calculate Table B-19, which shows the generic annualized cost summary including the 30 percent discount.

B.4 INSTALLATION OF STAGE II VAPOR RECOVERY SYSTEMS DURING THE CONSTRUCTION OF A NEW FACILITY

The additional dispenser costs incurred due to the installation of a Stage II system during the construction of a new facility are shown in Table B-20. This table is the same as Table B-2 except that incremental costs above the purchase of conventional refueling equipment were used.

The following specific changes were made:

1) The cost of a single nozzle swivel ($32.75 for an OPW-33 nozzle swivel, I-F-110) was subtracted from the cost of the vapor recovery swivel.

Table B-16. GENERIC STAGE II CAPITAL COST SUMMARY: NO DISCOUNTS (Retrofit to Existing Facility)

COMPONENT	COST OF COMPONENT		
	BALANCE	HYBRID	ASSIST
MODEL PLANT 1			
DISPENSER DIRECT COST	1,568	1,880	1,211
AUXILIARY DIRECT COST	0	0	5,238
PIPING DIRECT COST	3,910	3,700	4,120
TOTAL DIRECT COST	5,480	5,580	10,570
TOTAL INDIRECT COST	0	0	0
TOTAL CAPITAL COST	5,480	5,580	10,570
MODEL PLANT 2			
DISPENSER DIRECT COST	2,040	2,440	1,570
AUXILIARY DIRECT COST	0	0	5,238
PIPING DIRECT COST	4,950	4,810	4,620
TOTAL DIRECT COST	6,990	7,250	11,430
TOTAL INDIRECT COST	0	0	0
TOTAL CAPITAL COST	6,990	7,250	11,430
MODEL PLANT 3			
DISPENSER DIRECT COST	4,080	4,880	3,150
AUXILIARY DIRECT COST	0	0	5,238
PIPING DIRECT COST	7,860	7,720	7,000
TOTAL DIRECT COST	11,940	12,600	15,390
TOTAL INDIRECT COST	0	0	0
TOTAL CAPITAL COST	11,940	12,600	15,390
MODEL PLANT 4			
DISPENSER DIRECT COST	6,110	7,310	4,720
AUXILIARY DIRECT COST	0	0	5,238
PIPING DIRECT COST	9,690	9,650	9,140
TOTAL DIRECT COST	15,800	16,960	19,100
TOTAL INDIRECT COST	0	0	0
TOTAL CAPITAL COST	15,800	16,960	19,100
MODEL PLANT 5			
DISPENSER DIRECT COST	10,190	12,190	7,870
AUXILIARY DIRECT COST	0	0	5,238
PIPING DIRECT COST	12,650	12,720	11,580
TOTAL DIRECT COST	22,840	24,910	24,690
TOTAL INDIRECT COST	0	0	0
TOTAL CAPITAL COST	22,840	24,910	24,690

Table B-17. GENERIC STAGE II ANNUAL COST SUMMARY: NO DISCOUNTS
(Retrofit to Existing Facility)

COMPONENT	ANNUAL COST OF COMPONENT		
	BALANCE	HYBRID	ASSIST
MODEL PLANT 1			
CAPITAL RECOVERY COST	700	735	1,640
MAINTENANCE COST	475	497	436
INSPECTION COST	0	0	0
OTHER INDIRECT COSTS	220	223	423
RECOVERY CREDIT	129	129	65
ADDITIONAL CREDITS	0	0	0
TOTAL ANNUALIZED COST	1,270	1,330	2,430
MODEL PLANT 2			
CAPITAL RECOVERY COST	896	960	1,760
MAINTENANCE COST	617	646	537
INSPECTION COST	0	0	0
OTHER INDIRECT COSTS	280	290	457
RECOVERY CREDIT	518	518	259
ADDITIONAL CREDITS	0	0	0
TOTAL ANNUALIZED COST	1,280	1,380	2,500
MODEL PLANT 3			
CAPITAL RECOVERY COST	1,580	1,710	2,300
MAINTENANCE COST	1,230	1,292	970
INSPECTION COST	0	0	0
OTHER INDIRECT COSTS	478	504	616
RECOVERY CREDIT	906	906	453
ADDITIONAL CREDITS	0	0	0
TOTAL ANNUALIZED COST	2,380	2,600	3,430
MODEL PLANT 4			
CAPITAL RECOVERY COST	2,160	2,370	2,820
MAINTENANCE COST	1,852	1,938	1,410
INSPECTION COST	0	0	0
OTHER INDIRECT COSTS	633	679	765
RECOVERY CREDIT	1,683	1,683	841
ADDITIONAL CREDITS	0	0	0
TOTAL ANNUALIZED COST	2,960	3,300	4,150
MODEL PLANT 5			
CAPITAL RECOVERY COST	3,220	3,600	3,660
MAINTENANCE COST	3,090	3,230	2,280
INSPECTION COST	0	0	0
OTHER INDIRECT COSTS	914	996	987
RECOVERY CREDIT	4,790	4,790	2,400
ADDITIONAL CREDITS	0	0	0
TOTAL ANNUALIZED COST	2,430	3,040	4,530

Table B-18. GENERIC STAGE II CAPITAL COST SUMMARY: WITH DISCOUNTS (Retrofit to Existing Facility)

COMPONENT	COST OF COMPONENT		
	BALANCE	HYBRID	ASSIST
MODEL PLANT 1			
DISPENSER DIRECT COST	1,157	1,390	883
AUXILIARY DIRECT COST	0	0	5,238
PIPING DIRECT COST	3,910	3,700	4,120
TOTAL DIRECT COST	5,070	5,090	10,240
TOTAL INDIRECT COST	0	0	0
TOTAL CAPITAL COST	5,070	5,090	10,240
MODEL PLANT 2			
DISPENSER DIRECT COST	1,500	1,800	1,150
AUXILIARY DIRECT COST	0	0	5,238
PIPING DIRECT COST	4,950	4,810	4,620
TOTAL DIRECT COST	6,450	6,610	11,010
TOTAL INDIRECT COST	0	0	0
TOTAL CAPITAL COST	6,450	6,610	11,010
MODEL PLANT 3			
DISPENSER DIRECT COST	3,010	3,610	2,300
AUXILIARY DIRECT COST	0	0	5,238
PIPING DIRECT COST	7,860	7,720	7,000
TOTAL DIRECT COST	10,870	11,330	14,540
TOTAL INDIRECT COST	0	0	0
TOTAL CAPITAL COST	10,870	11,330	14,540
MODEL PLANT 4			
DISPENSER DIRECT COST	4,510	5,410	3,440
AUXILIARY DIRECT COST	0	0	5,238
PIPING DIRECT COST	9,690	9,650	9,140
TOTAL DIRECT COST	14,200	15,060	17,820
TOTAL INDIRECT COST	0	0	0
TOTAL CAPITAL COST	14,200	15,060	17,820
MODEL PLANT 5			
DISPENSER DIRECT COST	7,520	9,020	5,740
AUXILIARY DIRECT COST	0	0	5,238
PIPING DIRECT COST	12,650	12,720	11,580
TOTAL DIRECT COST	20,170	21,740	22,560
TOTAL INDIRECT COST	0	0	0
TOTAL CAPITAL COST	20,170	21,740	22,560

Table B-19. GENERIC STAGE II ANNUAL COST SUMMARY: WITH DISCOUNTS
(Retrofit to Existing Facility)

COMPONENT	ANNUAL COST OF COMPONENT		
	BALANCE	HYBRID	ASSIST
MODEL PLANT 1			
CAPITAL RECOVERY COST	623	644	1,580
MAINTENANCE COST	475	497	436
INSPECTION COST	0	0	0
OTHER INDIRECT COSTS	203	204	410
RECOVERY CREDIT	129	129	65
ADDITIONAL CREDITS	0	0	0
TOTAL ANNUALIZED COST	1,170	1,220	2,360
MODEL PLANT 2			
CAPITAL RECOVERY COST	832	880	1,710
MAINTENANCE COST	617	646	537
INSPECTION COST	0	0	0
OTHER INDIRECT COSTS	266	273	446
RECOVERY CREDIT	518	518	259
ADDITIONAL CREDITS	0	0	0
TOTAL ANNUALIZED COST	1,200	1,280	2,430
MODEL PLANT 3			
CAPITAL RECOVERY COST	1,380	1,480	2,140
MAINTENANCE COST	1,230	1,292	970
INSPECTION COST	0	0	0
OTHER INDIRECT COSTS	435	453	581
RECOVERY CREDIT	906	906	453
ADDITIONAL CREDITS	0	0	0
TOTAL ANNUALIZED COST	2,140	2,320	3,240
MODEL PLANT 4			
CAPITAL RECOVERY COST	1,860	2,010	2,580
MAINTENANCE COST	1,852	1,938	1,410
INSPECTION COST	0	0	0
OTHER INDIRECT COSTS	569	602	713
RECOVERY CREDIT	1,683	1,683	841
ADDITIONAL CREDITS	0	0	0
TOTAL ANNUALIZED COST	2,600	2,870	3,860
MODEL PLANT 5			
CAPITAL RECOVERY COST	2,720	3,010	3,260
MAINTENANCE COST	3,090	3,230	2,280
INSPECTION COST	0	0	0
OTHER INDIRECT COSTS	807	870	902
RECOVERY CREDIT	4,790	4,790	2,400
ADDITIONAL CREDITS	0	0	0
TOTAL ANNUALIZED COST	1,830	2,320	4,040

TABLE B-20. BALANCE DISPENSER MODIFICATION EQUIPMENT PURCHASE COST[a]
(New Facility)

COST OF COMPONENT

EXHIBIT 4

	LOW	HIGH	AVERAGE
HIGH HOSE RETRACTOR	94.00	102.50	96.08
SWIVELS-NOZZLES	9.65	42.25	22.12
SWIVELS-ISL OR DISP	21.50	21.50	21.50
SWIVELS-RETRACT	0.00	0.00	0.00
FLOW LIMITER	20.00	20.00	20.00
HOSE	13.50	35.28	24.39
DISP-HOOK & HANDLE	16.00	38.00	27.00
TOTAL PURCHASE COST	174.65	259.53	211.09

EXHIBIT 5

	LOW	HIGH	AVERAGE
HIGH HOSE RETRACTOR	94.00	102.50	96.08
SWIVELS-NOZZLES	7.25	26.05	16.65
SWIVELS-ISL OR DISP	41.55	64.85	53.20
SWIVELS-RETRACT	8.08	8.08	8.08
FLOW LIMITER	20.00	20.00	20.00
HOSE	75.61	75.61	75.61
DISP-HOOK & HANDLE	16.00	38.00	27.00
TOTAL PURCHASE COST	262.49	335.09	296.62

EXHIBIT 6

	LOW	HIGH	AVERAGE
HIGH HOSE RETRACTOR	94.00	102.50	96.08
SWIVELS-NOZZLES	9.65	42.25	22.12
SWIVELS-ISL OR DISP	21.50	21.50	21.50
SWIVELS-RETRACT	0.00	0.00	0.00
FLOW LIMITER	20.00	20.00	20.00
HOSE	44.56	55.45	50.00
DISP-HOOK & HANDLE	16.00	38.00	27.00
TOTAL PURCHASE COST	205.71	279.70	236.70

EXHIBIT 7

	LOW	HIGH	AVERAGE
HIGH HOSE RETRACTOR	94.00	102.50	96.08
SWIVELS-NOZZLES	9.65	42.25	22.12
SWIVELS-ISL OR DISP	0.00	0.00	0.00
SWIVELS-RETRACT	8.08	8.08	8.08
FLOW LIMITER	20.00	20.00	20.00
HOSE	13.50	35.28	24.39
DISP-HOOK & HANDLE	16.00	38.00	27.00
TOTAL PURCHASE COST	161.23	246.11	197.67
AVG TOTAL PURCHASE COST	201.02	280.11	360.00

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[a] See docket entries I-E-18, I-E-19, I-E-20, I-E-22, I-E-26, I-E-27, I-E-31, I-E-32, I-E-58, I-E-62, I-E-63, I-E-64, I-E-65, I-E-66, I-E-67, I-F-110, and I-F-111.

TABLE B-20. BALANCE DISPENSER MODIFICATION EQUIPMENT PURCHASE COST[a] (New Facility) (concluded)

Exhibit 8	Low	High	Avg.
Overhead Hose Retractor	94.00	102.50	96.08
Swivels for Nozzles	47.25	84.85	66.05
Swivels for Islands or Disp.	0.00	0.00	0.00
Swivel for Retractor	40.00	58.80	49.40
Flow Limiter	20.00	20.00	20.00
Hose	65.61	88.11	79.06
Liquid Removal Venturi	0.00	0.00	0.00
Dispenser Modification	38.00	55.00	46.50
	304.86	409.26	357.09

Exhibit 9	Low	High	Avg.
Overhead Hose Retractor	85.84	100.00	92.92
Swivels for Nozzles	47.25	84.85	66.05
Swivels for Islands or Disp.	0.00	0.00	0.00
Swivel for Retractor	40.00	58.80	49.40
Flow Limiter	20.00	20.00	20.00
Hose	70.61	94.36	84.53
Liquid Removal Venturi	0.00	0.00	0.00
Dispenser Modification	54.17	54.17	54.17
	317.87	412.18	367.07

Exhibit 10	Low	High	Avg.
Overhead Hose Retractor	0.00	0.00	0.00
Swivels for Nozzles	7.25	26.05	16.65
Swivels for Islands or Disp.	0.00	0.00	0.00
Swivel for Retractor	40.00	58.80	49.40
Flow Limiter	20.00	20.00	20.00
Hose	80.61	106.86	95.43
Liquid Removal Venturi	200.00	200.00	200.00
Dispenser Modification	54.17	54.17	54.17
	402.03	465.88	435.65

2) The cost of a single island or dispenser swivel ($17.25) was subtracted from the island or dispenser vapor recovery swivel cost. This subtracted cost is the average cost of the OPW-36E ($18.40), OPW-36S-5080 ($15.35), and the OPW-36S-5090 ($18.00) (I-F-110).
3) The cost of a single hose ($24.39) was subtracted from the coaxial hose cost shown in Exhibit 5.
4) For new facilities, it was assumed that 75 percent would use MPD's and 25 percent would use conventional dispensers.

Table B-21 shows the aboveground cost for the installation of a Stage II system during the construction of a new facility at model plant 2. This table is the same as Table B-4 except that the unit costs have changed as follows:

1) The nozzle cost for all the systems is the cost shown in Table B-4, minus the cost of a conventional nozzle ($50) (I-F-110 and I-F-111).
2) The modification equipment cost for a balance system is taken from Table B-20.
3) The modification cost for Assist-1 is the same as the balance cost plus the cost of a ball check valve ($17) (I-E-23).
4) The modification cost for the hybrid system includes the Model 100 jet pump, Model CX-6 adapter, Model S swivel, Model CX hoses, Model 143 control valve, and an installation kit, minus the cost of a single hose ($24.39) (I-E-25).
5) The installation cost for all systems is assumed to be zero. It was assumed that there would be no additional cost because the new dispensers would come equipped for Stage II.

The per-nozzle costs for model plants 1, 3, 4, and 5 are the same as those for model plant 2.

Table B-22 shows the underground cost incurred due to the installation of a Stage II system during the construction of a new facility at model plant 2. This table is the same as Table B-9 except it is assumed that there would be no additional cost for trenching since the product lines and vapor return lines could be put into the same trench, and no bungs are required since the tanks would already be equipped for Stage II. The same unit costs are used for piping lengths associated with model plants 1, 3, 4, and 5.

TABLE B-21. MODEL PLANT 2 STAGE II ABOVEGROUND DIRECT COST

ABOVEGROUND COMPONENTS	UNIT COST	NUMBER OF COMPONENTS				
DISPENSER COMPONENTS		BAL-I	BAL-M	HYBRID	ASSIST-1	ASSIST-2
NOZZLE BALANCE (a)	147	3.75	3.75			
NOZZLE HYBRID (b)	165			3.75		
NOZZLE ASSIST-1 (c)	128				3.75	
NOZZLE ASSIST-2 (d)	74					3.75
MOD EQUIP BALANCE (e)	360	3.75	3.75			
MOD EQUIP HYBRID (f)	411			3.75		
MOD EQUIP ASSIST-1 (g)	377				3.75	
MOD EQUIP ASSIST-2 (h)	205					3.75
AUXILIARY ITEMS (i)						
ASSIST-1	3,975				1.00	
ASSIST-2	3,900					1.00
INSTALLATION						
BALANCE DISPENSER	0	3.75	3.75			
HYBRID DISPENSER	0			3.75		
ASSIST-1 DISPENSER	0				3.75	
ASSIST-2 DISPENSER	0					3.75
ASSIST-1 AUXILIARY	1,400				1.00	
ASSIST-2 AUXILIARY	1,200					1.00
DISPENSER PURCHASE COST		1,901	1,901	2,159	1,892	1,046
AUX ITEMS PURCHASE COST		0	0	0	3,975	3,900
DISP INSTALLATION COST		0	0	0	0	0
AUX INSTALLATION COST		0	0	0	1,400	1,200
DISPENSER DIRECT COST		1,901	1,901	2,159	1,892	1,046
AUX ITEMS DIRECT COST		0	0	0	5,375	5,100
TOTAL DIRECT COST		1,901	1,901	2,159	7,267	6,146

(a) Average cost of nozzles certified by California for use with a balance system minus the cost of a normal nozzle ($50) (I-E-28, I-F-110, and I-F-111).

(b) Actual cost of the Healy Model 200 minus the cost of a normal nozzle ($50), (I-E-25).

(c) Average cost of the nozzles certified by California for use with the Hirt system minus the cost of a normal nozzle ($50), (I-E-28, I-F-110, and I-F-111).

(d) Actual cost of the Husky Model HP-2 nozzle minus the cost of a normal nozzle ($50), (I-F-106).

(e) Modification equipment includes the average cost of the high-hang retractor system, swivels, flow limiter, and hoses as certified by California (see Tables 1 and 20).

(f) Modification equipment includes the Model 100 jet pump, Model CX-6 adapter, Model S swivel, Model CX hose, Model 143 control valve, and an installation kit minus the cost of a single hose ($24.39), (I-E-25).

(g) Modification equipment includes the same equipment as listed for the balance system (footnote "f") plus a ball check valve (I-E-23 and Tables 1 and 2).

(h) Modification equipment includes the Hasstech vapor hose, ITT flow control valve, A.Y. McDonald impact valve, hose swivels, and Hasstech Model 1025 flame arrestor (I-F-106).

(i) Auxiliary equipment includes a P/V valve, collection unit, and processing unit (i-e-23).

TABLE B-22. MODEL PLANT 2 STAGE II UNDERGROUND DIRECT COST

UNDERGROUND COMPONENTS	UNIT COST	NUMBER OF COMPONENTS				
		BAL-I	BAL-M	HYBRID	ASSIST-1	ASSIST-2
GALVANIZED PIPE (a)						
1" PIPE (FT)	0.89	6	6	6	6	67
2" PIPE (FT)	1.88	2	2	2		
3" PIPE (FT)	3.86					
3/4" CLOSE NIPPLE	0.46	4	4	4	4	4
1" CLOSE NIPPLE	0.70	8	8	8	8	10
2" CLOSE NIPPLE	1.42	3	3	3		
3" CLOSE NIPPLE	5.41				2	
1" ELBOW	1.51	8	8	8	8	11
2" ELBOW	4.48	6	6	6		
3" ELBOW	20.11				2	
1" X 3/4" REDUCER	1.73	4	4	4	4	4
2" X 1" REDUCER	3.84	4	4	4	4	5
3" X 2" REDUCER	13.14					
2" X 1" BUSHING	2.81					1
4" X 2" BUSHING	11.09	3		3		1
4" X 3" BUSHING	11.09				1	
1" UNION	1.13					1
2" TEE	6.43					1
FIBERGLASS PIPE (b)						
2" PIPE (FT)	1.89	273	140	273	15	85
3" PIPE (FT)	2.89				83	
2" THREADED ADAPTER	7.23	7	7	7	4	6
3" THREADED ADAPTER	10.58				2	
2" ELBOW	16.41	6	3	6		4
3" ELBOW	22.82				2	
2" TEE	23.50	0	2	0		4
3" TEE	26.61		0		3	
2" COUPLING	4.68	8	2	8		3
3" COUPLING	7.23				2	
3" X 2" REDUCER	11.14		0		4	
GLUED JUNCTIONS	3.25	17	11	17	15	16
ADDITIONAL ITEMS (c)						
4" X 2" TANK BUSHING	2.61		3			
4" X 3" TANK BUSHING	2.61					
2" FLOAT CHECK VALVE	32.55		3			
VENT MANIFOLD DRUM (d)	500.00		1			
BUNGS (e)	0.00					
LABOR COMPONENTS						
TRENCHING (FT) (f)	0.00	105	105	105	85	130
ASSEMBLY (FT) (g)	6.00	105	105	105	85	130
TOTAL PURCHASE COST		869	1,140	869	646	550
TOTAL INSTALLATION COST		630	630	630	510	780
TOTAL DIRECT COST		1,499	1,770	1,499	1,156	1,330

See footnotes next page.

FOOTNOTES FOR TABLE B-22

[a] Reference I-E-33.

[b] Reference I-E-34.

[c] Reference I-F-110.

[d] Unit cost is an estimated cost since no information on this was readily available.

[e] Not needed on new tanks.

[f] Cost is absorbed in trenching cost for product lines.

[g] Reference I-E-46 (see text accompanying Table B-9 for discussion).

Tables B-23 and B-24 present the capital cost and annualized cost breakdown for the model plants. The same basic assumptions used in Tables B-14 and B-15 are used here; however, for new facilities more nozzles are assumed in the analysis based upon 25 percent single dispensers and 75 percent multiproduct dispensers (vs. 75 percent single dispensers and 25 percent multiproduct dispensers for existing facilities).

Table B-25 presents the generic capital cost summary for each Stage II system type on a model plant basis. The costs shown are used to compute generic annualized costs on a model plant basis, as shown in Table B-26. Table B-27 shows the generic Stage II capital cost summary, assuming the 30 percent discount for large volume buyers. This table is used to calculate Table B-28, which shows the generic annualized cost summary including the 30 percent discount.

TABLE B-23. STAGE II DIRECT COST SUMMARY (NEW FACILITY)

COMPONENT	COST OF COMPONENT				
	BAL-I	BAL-M	HYBRID	ASSIST-1	ASSIST-2
MODEL PLANT 1					
DISPENSER EQUIPMENT	1,775	1,775	2,015	1,766	977
AUXILIARY EQUIPMENT	0	0	0	3,975	3,900
UNDERGROUND PIPING	548	959	548	586	517
TOTAL PURCHASE COST	2,320	2,730	2,560	6,330	5,390
INSTALLATION COST	510	510	510	1,850	1,920
TOTAL DIRECT COST	2,830	3,240	3,070	8,180	7,310
MODEL PLANT 2					
DISPENSER EQUIPMENT	1,900	1,900	2,160	1,890	1,050
AUXILIARY EQUIPMENT	0	0	0	3,975	3,900
UNDERGROUND PIPING	869	1,140	869	646	550
TOTAL PURCHASE COST	2,770	3,040	3,030	6,510	5,500
INSTALLATION COST	630	630	630	1,910	1,980
TOTAL DIRECT COST	3,400	3,670	3,660	8,420	7,480
MODEL PLANT 3					
DISPENSER EQUIPMENT	3,800	3,800	4,320	3,780	2,090
AUXILIARY EQUIPMENT	0	0	0	3,975	3,900
UNDERGROUND PIPING	1,630	1,880	1,630	1,150	920
TOTAL PURCHASE COST	5,430	5,680	5,950	8,910	6,910
INSTALLATION COST	990	990	990	2,240	2,310
TOTAL DIRECT COST	6,420	6,670	6,940	11,150	9,220
MODEL PLANT 4					
DISPENSER EQUIPMENT	5,700	5,700	6,480	5,680	3,140
AUXILIARY EQUIPMENT	0	0	0	3,975	3,900
UNDERGROUND PIPING	2,120	2,200	2,130	1,580	1,410
TOTAL PURCHASE COST	7,820	7,900	8,610	11,240	8,450
INSTALLATION COST	1,230	1,230	1,230	2,480	2,640
TOTAL DIRECT COST	9,050	9,130	9,840	13,720	11,090
MODEL PLANT 5					
DISPENSER EQUIPMENT	9,510	9,510	10,790	9,460	5,230
AUXILIARY EQUIPMENT	0	0	0	3,975	3,900
UNDERGROUND PIPING	3,070	2,930	3,070	2,390	1,840
TOTAL PURCHASE COST	12,580	12,440	13,860	15,830	10,970
INSTALLATION COST	1,590	1,590	1,590	2,870	2,880
TOTAL DIRECT COST	14,170	14,030	15,450	18,700	13,850

Table B-24. STAGE II ANNUAL COST SUMMARY (NEW FACILITY)

COMPONENT/SYSTEM (a)	BAL-I	BAL-M	HYBRID	ASSIST-1	ASSIST-2
CAPITAL RECOVERY COST (b)					
MODEL PLANT 1	442	485	487	1,450	1,270
MODEL PLANT 2	512	540	560	1,480	1,290
MODEL PLANT 3	980	1,010	1,080	1,920	1,560
MODEL PLANT 4	1,420	1,420	1,560	2,350	1,840
MODEL PLANT 5	2,270	2,250	2,510	3,180	2,300
MAINTENANCE COST (c)					
MODEL PLANT 1	600	600	623	556	497
MODEL PLANT 2	643	643	668	588	525
MODEL PLANT 3	1,290	1,290	1,340	1,080	950
MODEL PLANT 4	1,930	1,930	2,000	1,560	1,370
MODEL PLANT 5	3,210	3,210	3,340	2,540	2,220
INSPECTION COST (d)					
MODEL PLANT 1	0	0	0	0	0
MODEL PLANT 2	0	0	0	0	0
MODEL PLANT 3	0	0	0	0	0
MODEL PLANT 4	0	0	0	0	0
MODEL PLANT 5	0	0	0	0	0
OTHER INDIRECT COSTS (e)					
MODEL PLANT 1	113	130	123	327	293
MODEL PLANT 2	136	147	146	337	299
MODEL PLANT 3	257	267	277	446	369
MODEL PLANT 4	362	365	393	548	444
MODEL PLANT 5	567	561	618	748	554
RECOVERY CREDITS (f)					
MODEL PLANT 1	129	129	129	65	65
MODEL PLANT 2	518	518	518	259	259
MODEL PLANT 3	906	906	906	453	453
MODEL PLANT 4	1,683	1,683	1,683	841	841
MODEL PLANT 5	4,790	4,790	4,790	2,395	2,395
ADDITIONAL CREDITS (g)					
MODEL PLANT 1	0	0	0	0	0
MODEL PLANT 2	0	0	0	0	0
MODEL PLANT 3	0	0	0	0	0
MODEL PLANT 4	0	0	0	0	0
MODEL PLANT 5	0	0	0	0	0
TOTAL ANNUALIZED COST					
MODEL PLANT 1	1,030	1,090	1,100	2,270	2,000
MODEL PLANT 2	770	810	860	2,150	1,860
MODEL PLANT 3	1,620	1,660	1,790	2,990	2,430
MODEL PLANT 4	2,030	2,030	2,270	3,620	2,810
MODEL PLANT 5	1,260	1,230	1,680	4,070	2,680

See next page for footnotes.

FOOTNOTES FOR TABLE B-24

[a] Assist-1 = Hirt; Assist-2 = Hasstech; Hybrid = Healy.

[b] Cost of Capital = $(\text{Capital Cost}) \dfrac{i(1+i)^a}{(1+i)^a - 1}$

where: i = interest rate (10 percent)
a = equipment life (8 years for dispenser and auxiliary equipment; 35 years for underground piping system)

[c] 1. Nozzle Maintenance - All Systems.
Replace nozzle every 2 years with new nozzle (same lifetime as standard nozzle); therefore annual cost equals half the incremental cost between standard nozzle ($50) and vapor recovery nozzle.

2. Hose Maintenance - All Systems.
Replace vapor hose every 2 years (same lifetime as liquid hose on standard dispenser); therefore, annual cost equals half the incremental cost between standard liquid hose ($24.39) and liquid/vapor recovery hose system ($110.73 from Exhibits 8-10, Table B-2).

3. Boot/Faceplate Assembly Maintenance - Balance Systems.
Replace boot/faceplate assembly three times per year; parts cost $19 per replacement and it takes 20 minutes per replacement at $25 per hour.

4. Boot/Faceplate Assembly Maintenance - Assist Systems.
Replace boot/faceplate assembly two times per year; parts cost $15 per replacement and it takes 20 minutes per replacement at $25 per hour.

5. Boot/Faceplate Assembly Maintenance - Hybrid Systems.
Replace boot/faceplate assembly two times per year; parts cost $33 per replacement and it takes 20 minutes per replacement at $25 per hour.

6. Processing Unit Maintenance - Assist Systems.
Maintenance performed once a year by a qualified professional at a cost of $100 per visit.

[d] This expense is included in the government enforcement costs and, thus, it is not attributable to the model plant annual cost.

[e] Value includes property tax (1%), insurance (1%), and administration (2%), equalling 4 percent of the total capital cost.

[f] Stage II recovery credit calculations:

Balance and Hybrid

Emission factors: Displacement = 1,552 mg/liter
Emptying loss = 120 mg/liter

FOOTNOTES FOR TABLE B-24
(concluded)

Assuming 95% recovery of both displacement and emptying losses, recovery factor = ((1,552 mg/liter)(.95)) + ((120 mg/liter)(.95)) = 1,588 mg/liter.

Example of recovery credit:

$$1{,}588\ \text{mg/liter} \times 75{,}700^{*}\ \frac{\text{liters}}{\text{mo.}} \times \frac{\text{kg}}{10^{6}\text{mg}} \times \frac{\text{liter}}{0.67\text{kg}} \times \frac{12\ \text{mo.}}{\text{yr}} \times \$0.24/\text{liter}$$

$$= \$518/\text{year.}$$

Assist 1 & 2

Assuming 50% recovery of balance system losses, recovery factor = (0.50)(0.95)(1,552 mg/liter) + (120 mg/liter) = 794 mg/liter.

Example of recovery credit:

$$794\ \text{mg/liter} \times 75{,}700^{*}\ \frac{\text{liters}}{\text{mo.}} \times \frac{\text{kg}}{10^{6}\text{mg}} \times \frac{\text{liter}}{0.67\text{kg}} \times \frac{12\ \text{mo.}}{\text{yr}} \times \$0.24/\text{liter}$$

$$= \$259/\text{year.}$$

[f] Throughout this analysis, the Model Plant 1 throughput used was 5,000 gallons per month to allow a comparison with the July 1984 analysis. However, the new analysis uses recovery credits based on Model Plant 1a (2,000 gallons per month) and Model Plant 1b (6,000 gallons per month) when calculating nationwide or nonattainment area cost impacts.

[g] No additional credits taken. These could include investment tax credits or energy conservation tax credits.

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*Throughput for model plant 2.

Table B-25. GENERIC STAGE II CAPITAL COST SUMMARY: NO DISCOUNTS (NEW STATION COSTS)

COMPONENT	COST OF COMPONENT		
	BALANCE	HYBRID	ASSIST
MODEL PLANT 1			
DISPENSER DIRECT COST	1,775	2,010	1,371
AUXILIARY DIRECT COST	0	0	5,238
PIPING DIRECT COST	1,260	1,060	1,140
TOTAL DIRECT COST	3,030	3,070	7,750
TOTAL INDIRECT COST	0	0	0
TOTAL CAPITAL COST	3,030	3,070	7,750
MODEL PLANT 2			
DISPENSER DIRECT COST	1,900	2,160	1,470
AUXILIARY DIRECT COST	0	0	5,238
PIPING DIRECT COST	1,630	1,500	1,240
TOTAL DIRECT COST	3,530	3,660	7,950
TOTAL INDIRECT COST	0	0	0
TOTAL CAPITAL COST	3,530	3,660	7,950
MODEL PLANT 3			
DISPENSER DIRECT COST	3,800	4,320	2,940
AUXILIARY DIRECT COST	0	0	5,238
PIPING DIRECT COST	2,740	2,620	2,010
TOTAL DIRECT COST	6,540	6,940	10,190
TOTAL INDIRECT COST	0	0	0
TOTAL CAPITAL COST	6,540	6,940	10,190
MODEL PLANT 4			
DISPENSER DIRECT COST	5,700	6,480	4,410
AUXILIARY DIRECT COST	0	0	5,238
PIPING DIRECT COST	3,390	3,360	2,750
TOTAL DIRECT COST	9,090	9,840	12,400
TOTAL INDIRECT COST	0	0	0
TOTAL CAPITAL COST	9,090	9,840	12,400
MODEL PLANT 5			
DISPENSER DIRECT COST	9,510	10,790	7,350
AUXILIARY DIRECT COST	0	0	5,238
PIPING DIRECT COST	4,590	4,660	3,690
TOTAL DIRECT COST	14,100	15,450	16,280
TOTAL INDIRECT COST	0	0	0
TOTAL CAPITAL COST	14,100	15,450	16,280

Table B-26. GENERIC STAGE II ANNUAL COST SUMMARY: NO DISCOUNTS (NEW STATION COSTS)

COMPONENT	ANNUAL COST OF COMPONENT		
	BALANCE	HYBRID	ASSIST
MODEL PLANT 1			
CAPITAL RECOVERY COST	464	487	1,360
MAINTENANCE COST	600	623	527
INSPECTION COST	0	0	0
OTHER INDIRECT COSTS	122	123	310
RECOVERY CREDIT	129	129	65
ADDITIONAL CREDITS	0	0	0
TOTAL ANNUALIZED COST	1,060	1,100	2,130
MODEL PLANT 2			
CAPITAL RECOVERY COST	526	560	1,390
MAINTENANCE COST	643	668	557
INSPECTION COST	0	0	0
OTHER INDIRECT COSTS	142	146	318
RECOVERY CREDIT	518	518	259
ADDITIONAL CREDITS	0	0	0
TOTAL ANNUALIZED COST	790	860	2,010
MODEL PLANT 3			
CAPITAL RECOVERY COST	1,000	1,080	1,740
MAINTENANCE COST	1,290	1,340	1,020
INSPECTION COST	0	0	0
OTHER INDIRECT COSTS	262	277	408
RECOVERY CREDIT	906	906	453
ADDITIONAL CREDITS	0	0	0
TOTAL ANNUALIZED COST	1,650	1,790	2,720
MODEL PLANT 4			
CAPITAL RECOVERY COST	1,420	1,560	2,100
MAINTENANCE COST	1,930	2,000	1,465
INSPECTION COST	0	0	0
OTHER INDIRECT COSTS	364	393	496
RECOVERY CREDIT	1,683	1,683	841
ADDITIONAL CREDITS	0	0	0
TOTAL ANNUALIZED COST	2,030	2,270	3,220
MODEL PLANT 5			
CAPITAL RECOVERY COST	2,260	2,510	2,740
MAINTENANCE COST	3,210	3,340	2,380
INSPECTION COST	0	0	0
OTHER INDIRECT COSTS	564	618	651
RECOVERY CREDIT	4,790	4,790	2,400
ADDITIONAL CREDITS	0	0	0
TOTAL ANNUALIZED COST	1,240	1,680	3,370

Table B-27. GENERIC STAGE II CAPITAL COST SUMMARY: WITH DISCOUNTS (NEW STATION COSTS)

COMPONENT	COST OF COMPONENT		
MODEL PLANT 1	BALANCE	HYBRID	ASSIST
DISPENSER EQUIPMENT	1,242	1,410	960
AUXILIARY EQUIPMENT	0	0	5,238
UNDERGROUND PIPING	1,260	1,060	1,140
TOTAL DIRECT COST	2,500	2,470	7,340
TOTAL INDIRECT COST	0	0	0
TOTAL CAPITAL COST	2,500	2,470	7,340
MODEL PLANT 2			
DISPENSER EQUIPMENT	1,330	1,510	1,030
AUXILIARY EQUIPMENT	0	0	5,238
UNDERGROUND PIPING	1,630	1,500	1,240
TOTAL DIRECT COST	2,960	3,010	7,510
TOTAL INDIRECT COST	0	0	0
TOTAL CAPITAL COST	2,960	3,010	7,510
MODEL PLANT 3			
DISPENSER EQUIPMENT	2,660	3,020	2,060
AUXILIARY EQUIPMENT	0	0	5,238
UNDERGROUND PIPING	2,740	2,620	2,010
TOTAL DIRECT COST	5,400	5,640	9,310
TOTAL INDIRECT COST	0	0	0
TOTAL CAPITAL COST	5,400	5,640	9,310
MODEL PLANT 4			
DISPENSER EQUIPMENT	3,990	4,530	3,090
AUXILIARY EQUIPMENT	0	0	5,238
UNDERGROUND PIPING	3,390	3,360	2,750
TOTAL DIRECT COST	7,380	7,890	11,080
TOTAL INDIRECT COST	0	0	0
TOTAL CAPITAL COST	7,380	7,890	11,080
MODEL PLANT 5			
DISPENSER EQUIPMENT	6,650	7,550	5,140
AUXILIARY EQUIPMENT	0	0	5,238
UNDERGROUND PIPING	4,590	4,660	3,690
TOTAL DIRECT COST	11,240	12,210	14,070
TOTAL INDIRECT COST	0	0	0
TOTAL CAPITAL COST	11,240	12,210	14,070

Table B-28. GENERIC STAGE II ANNUAL COST SUMMARY: WITH DISCOUNTS (NEW STATION COSTS)

COMPONENT	ANNUAL COST OF COMPONENT		
	BALANCE	HYBRID	ASSIST
MODEL PLANT 1			
CAPITAL RECOVERY COST	364	374	1,280
MAINTENANCE COST	600	623	527
INSPECTION COST	0	0	0
OTHER INDIRECT COSTS	100	99	294
RECOVERY CREDIT	129	129	65
ADDITIONAL CREDITS	0	0	0
TOTAL ANNUALIZED COST	940	970	2,040
MODEL PLANT 2			
CAPITAL RECOVERY COST	419	440	1,310
MAINTENANCE COST	643	668	557
INSPECTION COST	0	0	0
OTHER INDIRECT COSTS	119	120	300
RECOVERY CREDIT	518	518	259
ADDITIONAL CREDITS	0	0	0
TOTAL ANNUALIZED COST	660	710	1,910
MODEL PLANT 3			
CAPITAL RECOVERY COST	790	840	1,580
MAINTENANCE COST	1,290	1,340	1,020
INSPECTION COST	0	0	0
OTHER INDIRECT COSTS	216	226	373
RECOVERY CREDIT	906	906	453
ADDITIONAL CREDITS	0	0	0
TOTAL ANNUALIZED COST	1,390	1,500	2,520
MODEL PLANT 4			
CAPITAL RECOVERY COST	1,100	1,200	1,850
MAINTENANCE COST	1,930	2,000	1,465
INSPECTION COST	0	0	0
OTHER INDIRECT COSTS	296	316	443
RECOVERY CREDIT	1,683	1,683	841
ADDITIONAL CREDITS	0	0	0
TOTAL ANNUALIZED COST	1,640	1,830	2,920
MODEL PLANT 5			
CAPITAL RECOVERY COST	1,730	1,900	2,330
MAINTENANCE COST	3,210	3,340	2,380
INSPECTION COST	0	0	0
OTHER INDIRECT COSTS	450	489	563
RECOVERY CREDIT	4,790	4,790	2,400
ADDITIONAL CREDITS	0	0	0
TOTAL ANNUALIZED COST	600	940	2,870

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B.5 REFERENCES[a]

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[a] Numbers correspond to docket item numbers in Docket No. A-84-07.

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APPENDIX C

COMPARISON OF STAGE II COST ESTIMATES

APPENDIX C

COMPARISON OF STAGE II COST ESTIMATES

C.1 INTRODUCTION

This appendix compares Stage II per-facility costs estimated by the American Petroleum Institute (API), Sierra Research Corporation (Sierra), and the Environmental Protection Agency (EPA). Methodologies used by API and Sierra to calculate Stage II per-facility costs are discussed in Sections C.2 and C.3, respectively. These costs are then compared to the Stage II per-facility costs estimated by EPA (see Appendix B) in Section C.4, on an EPA model plant basis. Section C.4 also shows a comparison of API, Sierra, and EPA costs on an EPA model plant basis, with the cost annualization parameters (i.e., interest rates, component equipment lives, sales tax, certification cost, etc.) and recovery credits used by API and Sierra set equal to those used by EPA. All information regarding the API and Sierra cost estimates presented in this appendix was obtained from references I-D-42, I-E-30, I-F-98, and I-F-100. The EPA costs shown in this Appendix reflect the assumptions for retrofit to an existing facility (75 percent single dispensers and 25 percent multiproduct dispensers).

Throughout this appendix, balance-individual (Bal-I) refers to a Stage II balance system with an individual vapor return line from each pump to each storage tank. Balance-manifolded (Bal-M) refers to a balance system with the return lines from each pump at an island manifolded together so that there is a single vapor return line from each island to the leaded storage tank. The title Assist-1 is used to denote the Hirt system, Assist-2 is used for the Hasstech system, Hybrid-1 (Hyb-1) is used for the Healy system, and Hybrid-2 (Hyb-2) is used for the Red Jacket system.

C.2 API COST ESTIMATION METHODOLOGY

C.2.1 API Balance System Installed Cost

The API obtained data on the installed cost of a balance system, including cost and equipment life of components, by surveying eight companies with installation and operating experience in California. Costs were obtained for 6, 9, and 12-nozzle stations (see Table C-1).

The costs for 3, 15, and 18-nozzle stations were extrapolated from these data.

Incremental dispenser costs over the costs of conventional dispenser equipment were calculated by API. The costs of components for conventional and balance dispensers are shown in Table C-2. These data were also obtained by API from its survey of eight companies with operating experience in California. From these data, a total dispenser cost difference of \$324/nozzle was calculated.

A 12 percent engineering fee (as shown in Table C-1) and an installation permit fee (shown in Table C-3) were added to the total cost. Total piping costs were then calculated using the equation:

$$TPC = [(TCS + PF) - (ACBS - ACCS) \times NN] \times (1 + EC)$$

where:

TPC = Total Piping Cost
TCS = Total Cost of Station (from Table C-1)
PF = Permit Fee (from Table C-3)
ACBS = Average Dispenser Costs of a Stage II Balance System (\$432/nozzle from Table C-2)
ACCS = Average Dispenser Costs of a Conventional System (\$108/nozzle from Table C-2)
NN = Number of Nozzles/Station (3, 9, 12, 15, and 18)
EC = Engineering Cost (12%)

Installation costs for a Stage II balance system as reported by API are shown in Table C-4.

C.2.2 API Vacuum Assist System Installed Cost

API costs for the vacuum assist systems were obtained from three manufacturers of these systems. The cost data used in the API study were the lowest of those reported (I-D-42). Dispenser component costs were estimated to be slightly higher than for the balance displacement system dispenser components. Each assist system nozzle costs \$29.50 more than the balance nozzle, and includes a \$17/nozzle ball check valve not used in the balance system. Thus, the incremental dispenser component cost for the vacuum assist system (above conventional dispenser components) is \$324 + \$29.50 + \$17 = \$371/nozzle. As with the balance system, API added a 12 percent engineering cost and a permit fee (see Table C-3) to the total cost. The underground piping costs were assumed to be the same as for the balance system. Table C-5 presents the API

Table C-1. API SURVEY RESULTS: TOTAL COST OF RETROFITTING
A SERVICE STATION WITH A STAGE II BALANCE SYSTEM
(1983 Dollars, Reference I-E-30)

Survey Respondent		6 Nozzles		9 Nozzles		12 Nozzles
1	(7,600)	9,040[a]	(9,185)	11,345[a]	(10,900)	13,780[a]
2		10,500		14,700		17,000
3		4,200		6,300		8,400
4		9,840		12,770		16,685
5		13,224		NA[b]		NA[b]
6	(10,200)	11,640[a]	(12,500)	15,380[a]	(14,400)	17,280[a]
7		5,400		6,735		7,980
8		9,980		16,870		22,500
Average		9,240[c]		11,910		14,660
12% Engineering		1,110		1,430		1,760
Total		10,350		13,340		16,420

[a] High-hang retractor costs were not included in costs reported by respondents; therefore, a $240/nozzle cost was added by API to the respondents' costs. Numbers in parentheses are the costs reported by the respondent.

[b] Not reported by respondent.

[c] This average cost was reported by API but was not reproducible by EPA calculations (9,228 calculated from entries given).

Table C-2. API COST ESTIMATES OF CONVENTIONAL
AND BALANCE SYSTEM DISPENSER COMPONENTS
(Reference I-E-30)

Component	Conventional Dispenser Cost (Dollars)	Balance System Dispenser Cost (Dollars)	(Range)
Nozzle	60	144	(85-200)
Swivels	18	18	(15-25)
Hose	30	30	(15-48)
Retractor	0	240	(225-250)
Total	108	432	

Total Cost Difference = $324

Table C-3. API INSTALLATION PERMIT FEE ESTIMATES
(Reference I-F-98)

	Number of Nozzles						
	2[a]	3	6[a]	9	12	15	18
Cost($)	151	285	452	657	889	1,015	1,201

[a] Estimated by EPA so costs could be compared with EPA estimates for additional model plants as shown in Tables C-14, C-15, C-17, and C-18. Although API obtained data for a 6-nozzle station, they did not report an installation permit fee or capital costs for this size station.

Table C-4. API COST ESTIMATES FOR AN INSTALLED BALANCE SYSTEM
(Reference I-F-98)

Number of Nozzles/Outlet[a]	Installation Cost of Balance Displacement System (Dollars)		
	Dispenser Components	Piping	Total Cost
3	1,090	6,650[b]	7,740
9	3,270	10,730	14,000
12	4,360	12,950	17,310
15	5,440	15,070	20,510
18	6,530	17,250	23,780

[a] Although API obtained data for a 6-nozzle station, they did not report it in this table.

[b] This number was not reproducible and is inconsistent with the cost shown in the Table on page 3 of Appendix IV of the API report (i.e., 6,560).

installed cost estimates for a vacuum assist system for various sized stations. As noted in Tables C-4 and C-5, the piping costs are not reproducible for the 3-nozzle station. Also, the piping costs are supposed to be the same for the balance and vacuum assist systems, but, as can be seen, were reported differently for the 3-nozzle station.

Table C-5. API COST ESTIMATES FOR AN INSTALLED VACUUM ASSIST SYSTEM (Reference I-F-98)

		Costs in Dollars		
Number of Nozzles/Outlet[a]	Dispenser Components	Processor	Piping	Total
3	1,190	5,110	6,560[b]	12,860
9	3,560	5,220	10,730	19,510
12	4,750	5,280	12,950	22,980
15	5,910	5,340	15,070	26,320
18	7,130	5,390	17,250	29,770

[a] Although API obtained data for a 6-nozzle station, they did not report it in this table.

[b] This number is not consistent with its counterpart in Table C-4 (i.e., 6,650); most likely a calculation or typographical error.

C.2.3 API Maintenance Cost for Balance and Vacuum Assist Systems

Annual nozzle maintenance by dispensing outlet personnel was based on API estimates and incorporates three basic assumptions:

1) nozzles are exchanged for rebuilt nozzles yearly,
2) sealing face, retaining disc, bellows, and spring of balance system displacement nozzle are replaced by dispensing outlet personnel every 6 months, and
3) costs are calculated as incremental over standard dispensing outlets. (API states that the incremental cost was calculated several ways and the least expensive method was used.)

The incremental costs for nozzle replacement for both balance and vacuum assist nozzles are shown in Table C-6. Additional maintenance costs are shown in Table C-7.

Table C-6. API INCREMENTAL NOZZLE REPLACEMENT COST ESTIMATES (Reference I-F-98)

	Cost, $		
	Rebuilt Vapor Recovery Nozzle	Rebuilt Standard Nozzle	Incremental Cost
Balance System	100	17	83
Vacuum Assist System	75	17	58

Table C-7. ADDITIONAL MAINTENANCE COSTS ASSUMED BY API (Reference I-F-98)

Item	Cost, $
Nozzle Maintenance[a]	35/Nozzle
Hose Components	30/Nozzle
Hose Labor[b]	21/Nozzle
Annual Operating Permit Cost	150/Outlet
Processor Maintenance[c] (vacuum assist only)	279/Outlet
Ball Check Valve[d] (vacuum assist only)	1/Nozzle

[a] This cost was excluded by API in its analysis when calculating vacuum assist maintenance cost.

[b] Labor was estimated to be 45 minutes/year at $28/hr.

[c] Estimated as 10 percent of processor cost ($2,790).

[d] Estimated as 5 percent of ball check valve cost of $17.

C.2.4 API Annualized Cost

Total annualized costs consist of several variables: 1) annualized cost of capital, 2) maintenance costs, and 3) recovery credits. The API calculated the annual capital recovery cost by multiplying capital costs by a capital recovery factor. The capital recovery factor equals:

$$i(1+i)^a / (1+i)^a - 1,$$

where: i = the real return on invested money as a fraction, and

a = life of the equipment in years.

The average return for oil companies for the next 14 years was estimated to be 12.5 percent. However, the average inflation rate estimated by Data Resources, Inc., for 1982-1986 is 4.8 percent. Therefore, the real return on invested money was assumed by API to be 7.7 percent, or $i = 0.077$. Table C-8 shows the annualization factors used by API.

Table C-8. ANNUALIZATION FACTORS USED BY API
(Reference I-F-98)

Component Life (Years)	Annualization Factor
3	0.3859
8	0.1720
15	0.1147

The initial costs for the system were annualized over 3 years for dispensed equipment, 15 years for underground plumbing, and 8 years for processor equipment.

Recovery credits for returned gasoline were not calculated by API on a per-facility basis. The value of the returned fuel was calculated on a nationwide basis by multiplying national throughput by the following relationship for credits per gallon of gasoline dispensed:

$$\frac{(\text{grams hydrocarbon emitted/gallon dispensed gasoline})}{\text{density of gasoline}} \times$$

$$(\text{collection efficiency}) \times (\text{credit for returned fuel}),$$

where:

- grams hydrocarbon emitted/ gallon dispensed gasoline = 4 grams/gallon dispensed
- density of gasoline = 2,650 grams/gallon
- collection efficiency -
  - balance system = 95%
  - vacuum assist = 50%
- credit for returned fuel = $0.909/gallon

Table C-9 summarizes the cost estimates used by API for various size stations. As has been mentioned in Tables C-3, C-4, C-5, and C-9, several numbers reported by API were not reproducible using the methodology described in the API report. The one noticeable discrepancy is in the maintenance cost for 12, 15, and 18-nozzle stations, which appear to be in error by $22, $45, and $67, respectively, based on maintenance items shown in Table C-7 and those reported in Table C-9.

C.3 SIERRA COST ESTIMATION METHODOLOGY

C.3.1 Sierra Installed Balance, Aspirator Assist, and Vacuum Assist System Costs

Sierra obtained Stage II system costs from the California Air Resources Board (CARB) and from vendors of installed system components. The cost of an installed balance system was calculated by summing the costs for each individual component of the system. For comparison to EPA cost estimates, it was assumed that the "aspirator" assist system referred to by Sierra in its report was a Red Jacket (Hybrid 2) system since the Healy hybrid system does not have an "aspirator," but rather a "jet pump." It was also assumed that the assist system referred to by Sierra in its report was the Hasstech system since the diagram on page 8 of their report contains a blower (there is no blower associated with this generation Hirt system). The capital costs estimated by Sierra are shown in Table C-10. Sierra included a 10 percent discount on nozzle costs and a 5 percent sales tax on all component and installation costs.

Table C-9. SUMMARY OF API COST ESTIMATES FOR VARIOUS SIZE STATIONS

Balance Displacement System

	Number of Nozzles/Outlet[a]				
	3	9	12	15	18
Installation Cost, 1983 $	7,740	14,000	17,310	10,510	23,780
Maintenance Cost/Year, 1983 $	557[a]	1,671	2,156[b]	2,640[b]	3,125[b]
Control Efficiency, percent	<------ 95 ------>				
Recovery Credit	<------ $0.0013/gallon dispensed ------>				
Equipment Life, Years					
Dispenser Equipment	<------ 3 ------>				
Underground Piping	<------ 15 ------>				

[a] Although data were obtained for a 6 nozzle station, API did not report costs for a 6 nozzle station.

[b] This cost was not reproducible using methodology described by API.

Vacuum Assist

	Number of Nozzles/Outlet				
	3	9	12	15	18
Installation Cost, 1983 $	12,860	19,510	22,980	26,320	29,770
Maintenance Cost/Year, 1983 $	759[c]	1,418	1,747	2,077	2,405
Control Efficiency, percent	<------ 95 ------>				
Recovery Credit	<------ $0.000686/gallon dispensed ------>				
Equipment Life, Years					
Dispenser Equipment	<------ 3 ------>				
Underground Piping	<------ 15 ------>				
Processsor	<------ 8 ------>				

[c] This number is most likely a calculation or typographical error ($657 calculated from data given by API).

200

Table C-10. SIERRA CAPITAL COST ESTIMATES (Dollars)

Component	Manifolded Balance	Vacuum Assist	Aspirator Assist (Hybrid and Individual Balance)
Nozzle	198/nozzle	124/nozzle	161/nozzle
Dispenser Modifications	140/nozzle	200/nozzle	334/nozzle
Blower and Incinerator	0	3,500/outlet	0
Installation	175/nozzle	170/nozzle	225/nozzle
Blower Installation	0	2,000/outlet	0
Underground Piping (for initial island)	6,000/island[b]	5,000/island[b]	7,000/island[b]

[a] Installation costs include an overhead retractor.

[b] Plus $650 per each additional island. Cost tables are only for the first island.

C.3.2 Sierra Maintenance Costs for Balance, Aspirator Assist, and Vacuum Assist Systems

Routine maintenance items included by Sierra in their cost estimates were nozzles, boots, and faceplates. Nozzles and vapor lines were assumed to require replacement every 2 years. In the calculation of nozzle replacement costs, a $50 cost for replacement of a conventional nozzle was subtracted from the discounted cost of the vapor recovery nozzles. Vapor line replacement was estimated at $12/hose. The labor required for nozzle and dispenser maintenance was estimated to require 3 hours per year at a labor cost of $25 per hour. Each replacement of nozzle boots and faceplates was estimated to cost $19 per nozzle per replacement for a balance system, $15 per nozzle per replacement for a vacuum assist system, and $20 per nozzle per replacement for an aspirator assist system. These items were assumed to need replacement every 4 months, or three times per year.

C.3.3 Sierra Annualized Cost

Annualized costs were estimated by Sierra using the following assumptions:

- An annual investment tax credit of 10 percent and an energy conservation tax credit of 10 percent were applied to the entire system. This cost was annualized over 15 years.

- An annual permit fee of \$16/nozzle was also added to the annual cost.

- A property tax of 1 percent of the total capital cost of the Stage II system was added to the annual cost.

- Initial costs for the system were amortized over 20 years for the underground piping and 10 years for all other equipment.

- Annual costs for capital investment were calculated based on a 12 percent interest rate using the capital recovery factor formula:

$$\text{annual cost} = \text{capital cost} \times \frac{i(1+i)^{a}}{(1+i)^{a} - 1}$$

where:

i = interest rate (0.12)

a = amortization period.

The capital recovery factors used by Sierra are shown in Table C-11.

- Subtracted from the annual cost were the annualized value of the tax credit and the value of gasoline recovered (based on 4.7 grams of hydrocarbons recovered per gallon of gasoline dispensed, assuming 95 percent capture efficiency, \$0.90 per gallon of gasoline recovered, and a gasoline density of 2,806 grams per gallon). The throughputs used per facility are shown in Table C-12.

Table C-11. CAPITAL RECOVERY FACTORS USED BY SIERRA

Years	Recovery Factor
10[a]	0.177
15[b]	0.147
20[c]	0.134

[a] Used to calculate annualized cost of capital for dispenser equipment, processors, and nozzles.

[b] Used to calculate annualized ITC and energy tax credits.

[c] Used to calculate annualized cost of capital for underground piping.

Table C-12. THROUGHPUTS USED BY SIERRA FOR CALCULATION OF PRODUCT RECOVERY CREDITS

Number of Nozzles	Number of Islands	Average Throughput (gallons/month)
2	1	14,000
6	2	30,000
8	2	55,000
12	4	100,000
16	4	250,000

An example of Sierra cost calculations for the installation of an aspirator assist system on a 4-island, 16-nozzle, 250,000 gallon throughput/month station follows:

Capital Investment: (see Table C-10)

piping: (($7,000 for first island) + (3 islands x $650/island))
x (1.05 sales tax) = $9,398

nozzles: (($161/nozzle) x (1 - 0.1 discount)) x (16 nozzles)
x (1.05 sales tax) = 145 x 16 x 1.05 = $2,436

dispenser modification:
($334/nozzle) x (16 nozzles) x (1.05 sales tax) = $5,611

installation: ($225/nozzle) x (16 nozzles) x (1.05 sales tax) = $3,780

Total Capital Cost = $21,225.

Annualized Cost of Capital Investment:

[($9,398 piping cost) x (0.134 capital recovery factor from Table C-11)]
+ [($2,438 nozzle cost + $5,611 dispenser modification cost + $3,780 installation cost)
x (0.177 capital recovery factor from Table C-11)]
= $3,353.

Annual Maintenance:

boots, faceplates, and labor:

[(($20/nozzle replacement) x (3 replacements/year) x (1.05 sales tax)) +
((3 labor hours/nozzle-year) x ($25/hr))] x (16 nozzles)
= $2,208.

nozzles and vapor hoses:

[(((($161/nozzle) x (1 - 0.1 discount)) - ($50/conventional nozzle)) / (2 years/replacement)) + (($12/vapor hose) / (2 years/replacement))] x (16 nozzles) x (1.05 sales tax) = (48 + 6) x 16 x 1.05 = $907

Subtotal = $3,115.

Annual Permit Fee: ($16/nozzle) x (16 nozzles) = $256.

Annual Property Tax:

($21,225 x capital cost) x (0.01 property tax) = $212.

Annualized ITC/Energy Tax Credit:

($21,225 capital cost) x [(0.1 investment tax credit) + (0.1 energy tax credit)] x (0.147 capital recovery factor from Table C-11) =

= ($624) credit.

Annual Product Recovery:

[(250,000 gallons dispensed/month) x (12 months/year) x (4.7 grams recovered/gallon dispensed) x ($0.90/gallon)] / (2,806 grams/gallon of gasoline)

= ($4,522) credit.

Total Annualized Cost:

$3,353 + $3,115 + $256 + $212 - $624 - $4,522 = $1,790.

Cost Per Megagram of Hydrocarbon Controlled

$1,790 annualized cost / ((250,000 gallons dispensed/month) x (12 months /year) x (4.7 grams recovered/gallon dispensed)) x (10^6 gm/Mg)

= $127/Mg recovered.

Table C-13 summarizes the Stage II per-facility capital costs and annual maintenance costs estimated by Sierra.

C.4 COMPARISON OF STAGE II COST ESTIMATES

A direct comparison of EPA, Sierra, and API cost estimations was difficult to make because each analysis used different facility gasoline throughputs, number of nozzles per facility, and number of islands per facility. However, Figures C-1 through C-4 graphically display both the capital and annualized costs for each analysis on a per-nozzle basis and a per-facility throughput basis. EPA per-facility throughputs

Table C-13. SIERRA CAPITAL AND ANNUAL MAINTENANCE COST ESTIMATES

COST COMPONENT	SYSTEM (a)			
	BAL-IND	BAL-MAN	HYB-2	ASSIST-2
DISPENSER CONVERSION ($/NOZZLE)				
NOZZLES	198	198	161	124
MODIFICATION EQUIPMENT (b)	140	140	334	200
LABOR (c)	175	175	225	170
TOTAL DISPENSER COST	513	513	720	494
AUXILIARY EQUIPMENT ($/STATION)				
PROCESSING UNIT (d)				3,500
LABOR				2,000
TOTAL AUXILIARY COST (e)	0	0	0	5,500
UNDERGROUND PIPING ($/STATION)				
2 NOZZLE STATION	7,000	6,000	7,000	5,000
6 NOZZLE STATION	7,650	6,650	7,650	5,650
8 NOZZLE STATION	7,650	6,650	7,650	5,650
12 NOZZLE STATION	8,950	7,950	8,950	6,950
16 NOZZLE STATION	8,950	7,950	8,950	6,950
TOTAL EQUIPMENT & LABOR COST				
2 NOZZLE STATION	8,026	7,026	8,440	11,488
6 NOZZLE STATION	10,728	9,728	11,970	14,114
8 NOZZLE STATION	11,754	10,754	13,410	16,402
12 NOZZLE STATION	15,106	14,106	17,590	18,378
16 NOZZLE STATION	17,158	16,158	20,470	20,354
ADDITIONAL CAPITAL COSTS (f)				
2 NOZZLE STATION	359	309	388	549
6 NOZZLE STATION	410	360	498	630
8 NOZZLE STATION	420	370	536	719
12 NOZZLE STATION	503	453	678	768
16 NOZZLE STATION	522	472	755	816
TOTAL CAPITAL COST				
2 NOZZLE STATION	8,385	7,335	8,828	12,037
6 NOZZLE STATION	11,138	10,088	12,468	14,744
8 NOZZLE STATION	12,174	11,124	13,946	17,121
12 NOZZLE STATION	15,609	14,559	18,268	19,146
16 NOZZLE STATION	17,680	16,630	21,225	21,170
DISPENSER MAINTENANCE ($/NZ/YR)				
NOZZLES (g)	67	67	50	33
HOSES (h)	6	6	6	6
BOOTS AND FACEPLATES (i)	135	135	138	122
BALL CHECK VALVE (j)				
TOTAL DISPENSER MAINTENANCE COST	208	208	195	161
ADDITIONAL MAINTENANCE ($/STAT/YR)				
PROCESSING UNIT (j)				
TOTAL ANNUAL MAINTENANCE COST (k)				
MODEL PLANT 1	417	417	389	322
MODEL PLANT 2	1,250	1,250	1,168	967
MODEL PLANT 3	1,667	1,667	1,558	1,289
MODEL PLANT 4	2,500	2,500	2,336	1,933
MODEL PLANT 5	3,334	3,334	3,115	2,578

See next page for footnotes.

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Footnotes for Table C-13

(a) Balance-Ind = Balance Individual; Hyb-2 = Red Jacket; Assist-2 = Hasstech.

(b) Balance-Ind and Manifolded: Includes cost of anti-recirculation valve, flow limiter, hose swivels, new liquid hose and vapor recovery hose, and hanger kit.

Hyb-2: Includes aspirator, new liquid hose and vapor recovery hose, hose swivels, and hanger kit.

Assist-2: Includes cost of check valve, flame arrestor, vapor hose, and hanger kit.

(c) Sierra's labor cost for each system includes the cost of an overhead hose retractor system.

(d) Cost includes collection unit (blower, turbine, etc.), control panel, processor, and pressure/vacuum valve for manifolded vent risers.

(e) Manifolded balance system piping is $6,000 for first island, plus $650 per additional island.

(f) An average discount of 10 percent on the cost of nozzles is included in the "Total Capital Cost" values, also a $50 cost for standard nozzle is subtracted from vapor recovery nozzle costs. Sierra also computes a 5 percent sales tax on the "Total Equipment and Labor Cost" value after the nozzle discount is applied and includes this tax in the "Total Capital Cost" values (e.g., for a 6-nozzle balance individual system, cost = 6 ((198 x 0.1) - 50) = 181).

(g) Sierra replaces every 2 years with a new nozzle (same lifetime as standard nozzle); therefore, annual cost equals half the incremental cost between standard ($50) and vapor recovery nozzles. The nozzle cost includes a 5% sales tax. Example for balance individual nozzle, cost = [((198)(0.9) - 50) (1.05)]/2 = 67.

(h) Sierra replaces a vapor hose ($12) every 2 years. The hose cost includes a 5% sales tax. All boots and faceplate equipment costs also include a 5% sales tax.

(i) Balance-Ind and Manifolded: replace three times per year, parts cost $19 per replacement, and 1 hour labor per replacement at $25 per hour (e.g., 19 X 1.05 x 3 + (3 x 25) = 135).

Hyb-2: replace three times per year, parts cost $20 per replacement, and 1 hour labor per replacement at $25 per hour (e.g., 20 x 1.05 x 3 + (3 X 25) = 138).

Footnotes for Table C-13 (concluded)

Assist-2:

replace three times per year, parts cost $15 per replacement, and 1 hour labor per replacement at $25 per hour (e.g., 15 x 1.05 x 3 + (3 x 25) = 122).

(j) No cost given.

(k) Costs include a 5 percent sales tax on equipment.

Figure C-1

STAGE II PER—FACILITY CAPTITAL COST

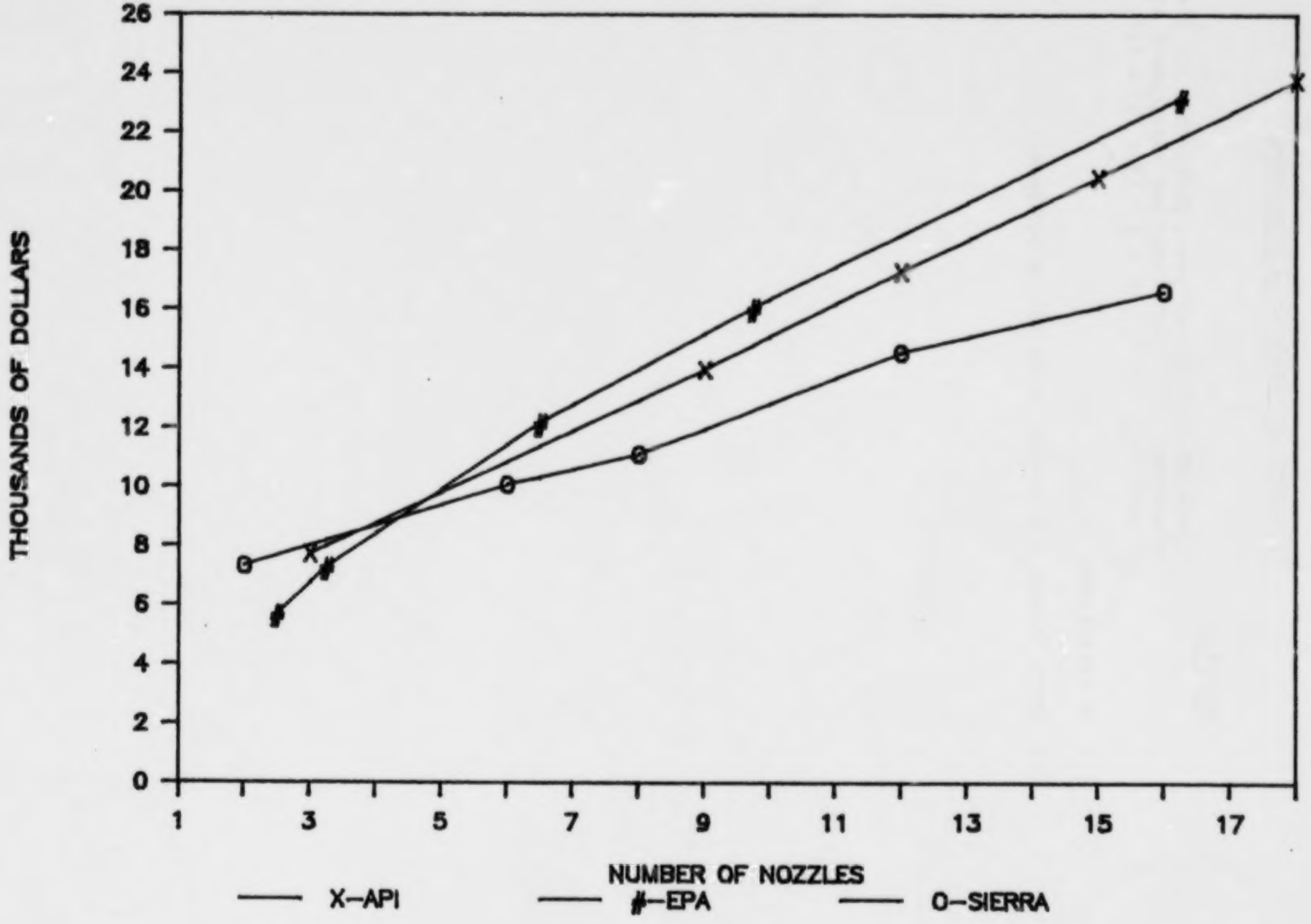


Figure C-2

STAGE II PER—FACILITY ANNUAL COST

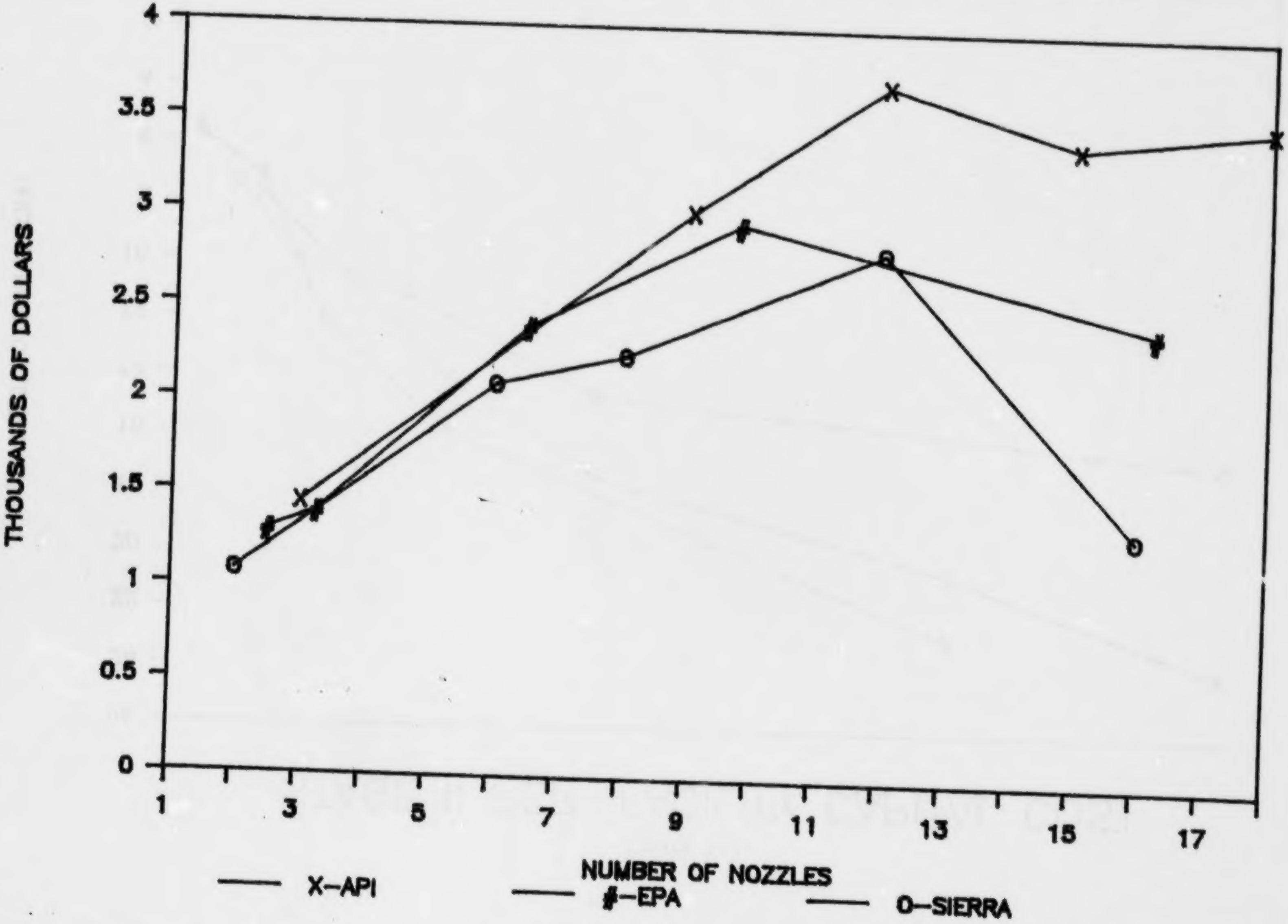


Figure C-3.

STAGE II PER-FACILITY CAPITAL COST

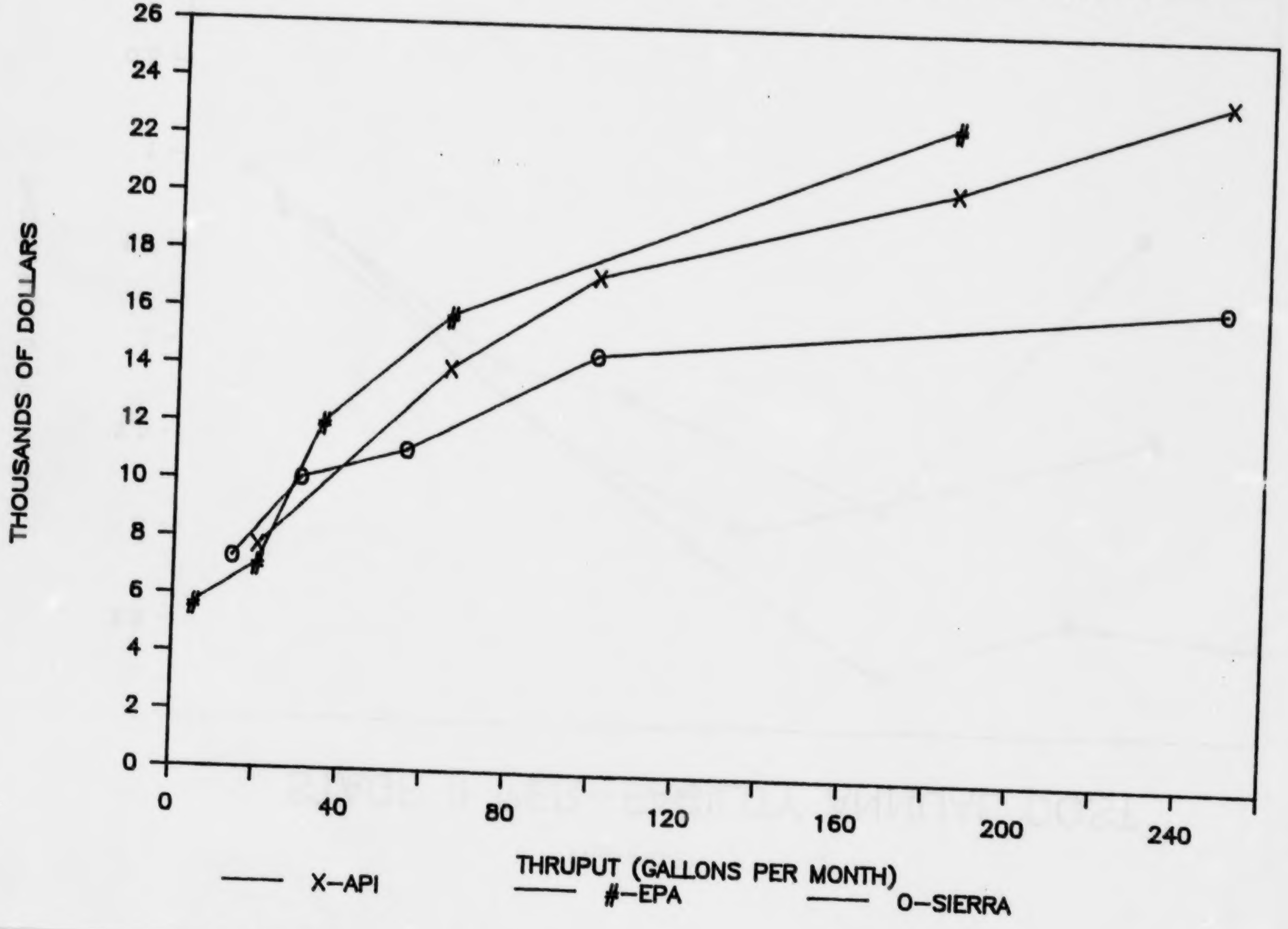
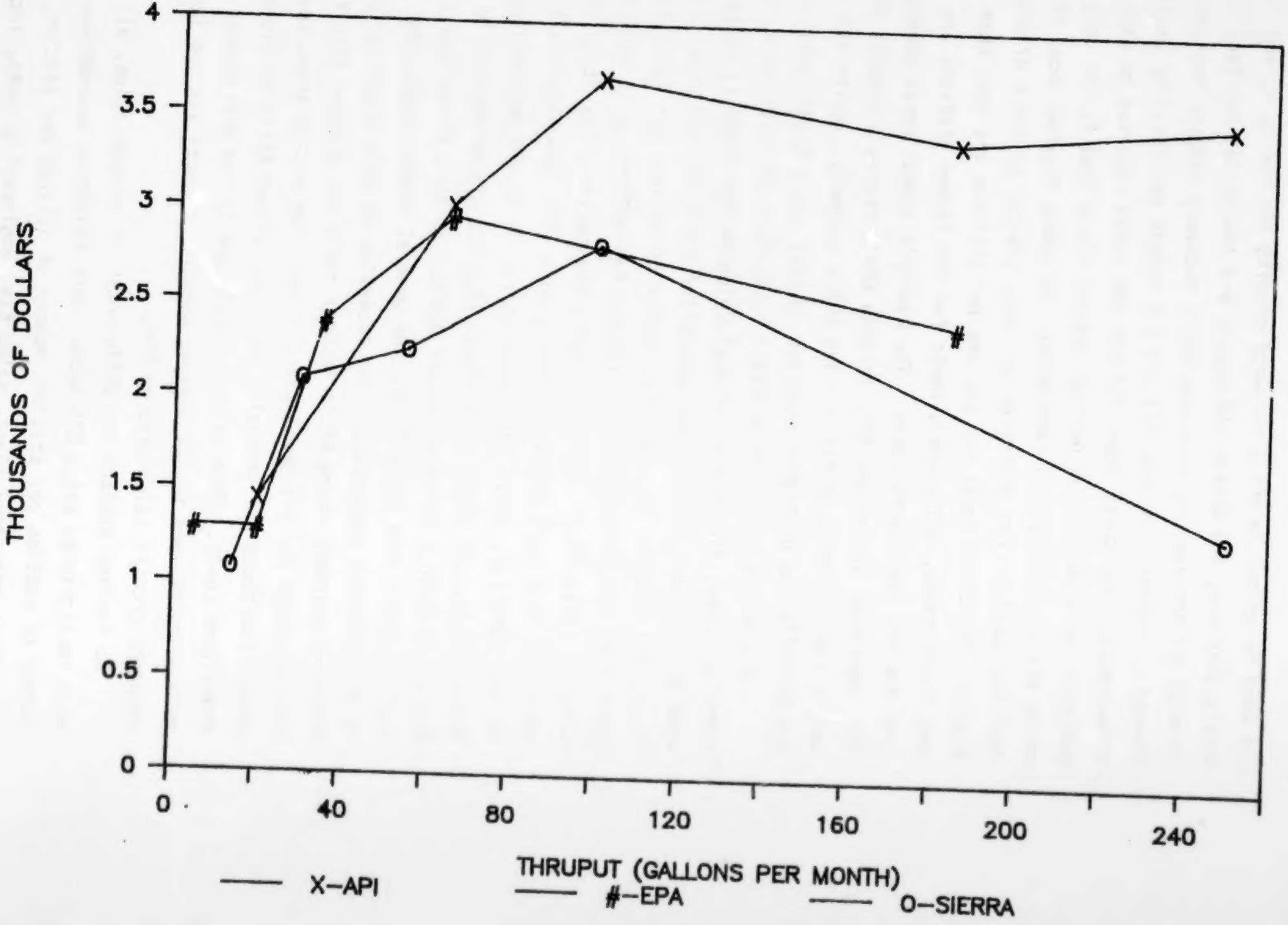


Figure C-4.

STAGE II PER-FACILITY ANNUAL COST



are used to calculate API's recovery credits for the 3, 9, and 15-nozzle stations, and Sierra (12-nozzle and 16-nozzle) per-facility throughputs are used to calculate API's recovery credits for the 12 and 18-nozzle stations, because API did not supply per-facility gasoline throughputs. The costs shown reflect the costs reported by each analysis for a manifolded balance system, since that is the only system which all of the analyses considered. As these figures show, EPA per-facility capital cost estimates are very similar to those of API and Sierra. The EPA's costs for the smaller stations are less than the API and Sierra costs, while EPA's costs for the larger stations are greater than the API and Sierra costs. The Agency's annual costs generally are less than both Sierra and API, because EPA's recovery credits are so much larger than Sierra's or API's. The EPA's recovery credits are larger due to EPA's use of higher emission factors and a higher cost of gasoline.

In order to make a more direct comparison of costs among the three analyses, Sierra and API methodologies for Stage II costs were used to calculate capital and annualized costs for EPA model plants (i.e., EPA nozzles per facility, number of islands per facility, and throughput per facility; see Table B-8 for definition of each EPA model plant). Tables C-14 and C-15 present the per-facility Stage II capital and annualized cost estimates developed by EPA (see Appendix B for further details), those calculated using the Sierra methodology (see Section C-3), and those calculated using the API methodologies (see Section C-2) on a per-model plant basis. In this comparison of capital costs (see Table C-14), the general trends remain the same as in the previous comparison. One exception to this trend is for Assist-1 systems, where API's capital costs are greater than EPA's capital costs for all model plant sizes. Table C-15 shows that EPA's annualized costs are generally less than either API's or Sierra's annualized costs. This is most likely due to the differences in methodologies used in calculating annualized costs and the larger recovery credits calculated by EPA.

To further explore the differences in methodologies, all costs were recalculated using EPA model plant financial assumptions (i.e., number of nozzles per station, number of islands per station, gasoline throughput per model plant, sales tax, engineering costs, interest

Table C-14. CAPITAL AND ANNUAL MAINTENANCE COST SUMMARY USING EPA MODEL PLANT PARAMETERS

SYSTEM (a)	BALANCE-IND		BALANCE-MANIFOLDED			HYB-1	HYB-2	ASSIST-1		ASSIST-2	
COST COMPONENT	EPA	SIERRA	EPA	SIERRA	API	EPA	SIERRA	EPA	API	EPA	SIERRA
DISPENSER CONVERSION ($/NOZZLE)											
NOZZLES (b)	197	198	197	198	84	215	161	178	114	124	124
MODIFICATION EQUIPMENT (c)	350	140	350	140	240	435	334	367	240	205	200
LABOR (d)	80	175	80	175	0	100	225	45	0	50	170
TOTAL DISPENSER COST	627	513	627	513	324	750	720	590	354	379	494
AUXILIARY EQUIPMENT ($/STATION)											
PROCESSING UNIT (e)	—	—	—	—	—	—	—	3,975	(f)	3,900	3,500
LABOR	—	—	—	—	—	—	—	1,400	(f)	1,200	2,000
TOTAL AUXILIARY COST	0	0	0	0	0	0	0	5,375	(f)	5,100	5,500
UNDERGROUND PIPING ($/STATION)											
MODEL PLANT 1	3,700	7,000	4,130	6,000	5,026	3,700	7,000	3,330	5,026	4,900	5,000
MODEL PLANT 2	4,810	7,000	5,090	6,000	5,603	4,810	7,000	3,850	5,603	5,300	5,000
MODEL PLANT 3	7,720	7,650	7,990	6,650	7,293	7,720	7,650	6,290	7,293	7,710	5,650
MODEL PLANT 4	9,640	8,300	9,750	7,300	8,994	9,650	8,300	8,140	8,994	10,150	6,300
MODEL PLANT 5	12,720	8,950	12,580	7,950	12,558	12,720	8,950	11,200	12,558	11,950	6,950
TOTAL EQUIPMENT & LABOR COST											
MODEL PLANT 1	5,270	8,283	5,700	7,283	5,836	5,580	8,800	10,180	10,473	10,950	11,735
MODEL PLANT 2	6,850	8,667	7,130	7,667	6,656	7,250	9,340	11,140	11,314	11,710	12,756
MODEL PLANT 3	11,800	10,985	12,070	9,985	9,399	12,600	12,330	15,500	14,202	15,270	15,011
MODEL PLANT 4	15,750	13,302	15,860	12,302	12,153	16,960	15,320	19,260	17,101	18,950	17,257
MODEL PLANT 5	22,910	17,286	22,770	16,286	17,823	24,910	20,650	26,150	23,070	23,210	20,478
ADDITIONAL CAPITAL COSTS (g)											
MODEL PLANT 1	0	362	0	312	851	0	398	0	1,407	0	555
MODEL PLANT 2	0	365	0	315	1,084	0	412	0	1,643	0	597
MODEL PLANT 3	0	413	0	363	1,500	0	507	0	2,156	0	669
MODEL PLANT 4	0	460	0	410	2,115	0	602	0	2,709	0	740
MODEL PLANT 5	0	523	0	473	3,154	0	760	0	3,783	0	819
TOTAL CAPITAL COST											
MODEL PLANT 1	5,270	8,644	5,700	7,594	6,690	5,580	9,198	10,180	11,880	10,950	12,290
MODEL PLANT 2	6,850	9,032	7,130	7,982	7,740	7,250	9,752	11,140	12,960	11,710	13,352
MODEL PLANT 3	11,800	11,397	12,070	10,347	10,900	12,600	12,837	15,500	16,360	15,270	15,680
MODEL PLANT 4	15,750	13,762	15,860	12,712	14,270	16,960	15,922	19,260	19,810	18,950	18,007
MODEL PLANT 5	22,910	17,809	22,770	16,759	20,980	24,910	21,410	26,150	26,850	23,210	21,297
DISPENSER MAINTENANCE ($/NZ/YR)											
NOZZLES (h)	65	67	65	67	83	73	50	56	58	32	33
HOSES (i)	43	6	43	6	51	43	6	43	51	43	6
BOOTS AND FACEPLATES (j)	82	135	82	135	35	83	138	47	0	47	122
BALL CHECK VALVE (k)	—	—	—	—	—	—	—	—	1	—	—
TOTAL DISPENSER MAINTENANCE COST	190	208	190	208	169	199	195	146	110	123	161
ADDITIONAL MAINTENANCE ($/STAT/YR)											
PROCESSING UNIT (l)	—	—	—	—	—	—	—	100	279	100	—
TOTAL ANNUAL MAINTENANCE COST											
MODEL PLANT 1	475	521	475	521	423	497	487	465	554	406	403
MODEL PLANT 2	620	677	617	677	549	646	633	575	636	498	524
MODEL PLANT 3	1,230	1,354	1,230	1,354	1,099	1,290	1,266	1,050	993	897	1,047
MODEL PLANT 4	1,850	2,031	1,850	2,031	1,648	1,940	1,898	1,530	1,350	1,290	1,571
MODEL PLANT 5	3,090	3,386	3,090	3,386	2,746	3,230	3,164	2,480	2,064	2,090	2,618

See next page for footnotes.

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Footnotes for Table C-14

(a) Hyb-1 = Healy; Hyb-2 = Red Jacket; Assist-1 = Hirt; Assist-2 = Hasstech.

(b) API calculates incremental cost between standard nozzle ($60) and vapor recovery nozzle ($144 for balance nozzle and $174 for assist nozzle).

(c) Balance-Ind

EPA: includes cost of overhead hose retractor system, applicable swivels, flow limiter, hanger kit, and the incremental cost between a standard liquid hose and a liquid/vapor recovery hose system.

Sierra: includes cost of anti-recirculation valve, flow limiter, hose swivels, new liquid hose and vapor recovery hose, and hanger kit.

Balance-Manifolded

EPA: same as Balance-Ind for EPA.
Sierra: same as Balance-Ind for Sierra.
API: includes swivels, hoses, and retractors.

Hyb-1

EPA: includes cost of Model 100 jet pump, Model CX-6 adapter, installation kit, Model S swivel, Model 143 control valve, and incremental cost between standard liquid hose and Model CX hose.

Hyb-2

Sierra: includes aspirator, new liquid hose and vapor recovery hose, hose swivels, and hanger kit.

Assist-1

EPA: same as Balance-Ind for EPA plus cost of ball check valve.

API: same as Balance-Manifolded.

Assist-2

EPA: cost obtained from Hasstech, Inc. (see Appendix B); no specific component breakdown given. Sierra: includes cost of check valve, flame arrestor, vapor hose, and hanger kit.

(d) Sierra's labor cost for each system includes the cost of an overhead hose retractor system.

(e) Cost includes collection unit (blower, turbine, etc.), control panel, processor, and pressure/vacuum valve for manifolded vent risers.

(f) Total processor costs estimated by API are:

Model plant 1:	$4,563*
Model plant 2:	$4,563
Model plant 3:	$4,612*
Model plant 4:	$4,714
Model plant 5:	$4,768

*Estimated by EPA from data presented by API.

Footnotes for Table C-14 (continued)

(g) Sierra: an average discount of 10% on the cost of nozzles and a 5% sales tax on the "Total Equipment and Labor Cost" is applied (e.g., for a balance-individual system, Model Plant 2: additional cost = - ($198/nozzle x 0.1 nozzle discount x 3 nozzles/model plant x 1.05 sales tax) + ($8,539 total equipment and labor costs x 0.05 sales tax) = -($20 x 3 x 1.05) + ($8,539 x (1.05 - 1) = - 63 + 427 = $364.

API: a 12% engineering cost on "Total Equipment and Labor Cost" and an installation fee (see Table C-3) is applied (e.g., for a balance manifolded system, Model Plant 3: additional cost = ($9,237 equipment and labor cost) x (0.12 engineering cost) + ($452 installation fee) = $1,560.

EPA: engineering and inspection costs were not included in the EPA analysis.

(h) EPA: replace every 2 years with new nozzle (same lifetime as standard nozzle); therefore, annual cost equals half the incremental cost between standard ($50) and vapor recovery nozzles. Multiproduct dispenser nozzle life considered twice that of conventional dispenser.

Sierra: replace every 2 years with new nozzle (same lifetime as standard nozzle; therefore, annual cost equals half the incremental cost between standard ($50) and vapor recovery nozzles. The 10% nozzle discount and 5% sales tax are also included in this price (e.g., balance-individual nozzle replacement = [($198/nozzle x 0.9 discount) - $50/conventional nozzle] x 1.05 sales tax x 1/2 replacement per year = [(178 - 50) x 1.05] /2 = $67/nozzle.

API: replace nozzles every year with rebuilt nozzle; cost presented includes deduction for standard rebuilt nozzle ($17).

(i) EPA: replace every 2 years (same lifetime as liquid hose on standard dispenser); therefore, annual cost equals half the incremental cost between standard liquid hose ($24) and coaxial liquid/vapor recovery hose system.

Sierra: replace vapor hose ($12) every 2 years.

API: annual equipment costs (including retractors) average $30 and labor averages $21 per year.

Footnotes for Table C-14 (concluded)

(j) Balance-Ind

EPA: replace three times per year; parts cost $19 per replacement, and 20 minutes labor per replacement at $25 per hour.

Sierra: replace three times per year, parts cost $19 per replacement, and 1 hour labor per replacement at $25 per hour.

Balance-Manifolded

EPA: replace three times per year; parts cost $19 per replacement, and 20 minutes labor per replacement at $25 per hour.

Sierra: replace three times per year; parts cost $19 per replacement, and 1 hour labor per replacement at $25 per hour.

API: replace two times per year.

Hyb-1

EPA: replace two times per year; parts cost $33 per replacement, and 20 minutes labor per replacement at $25 per hour.

Hyb-2

Sierra: replace three times per year; parts cost $20 per replacement, and 1 hour labor per replacement at $25 per hour.

Assist-1

EPA: replace two times per year; parts cost $15 per replacement, and 20 minutes labor per replacement at $25 per hour.

API: replace two times per year.

Assist-2

EPA: replace two times per year; parts cost $15 per replacement, and 20 minutes labor per replacement at $25 per hour.

Sierra: replace three times per year; parts cost $15 per replacement, and 1 hour labor per replacement at $25 per hour.

(k) API assumed an annual maintenance cost equalling 5 percent of component cost (i.e., $17 x 0.05 = $1).

(l) EPA: maintenance time per year at $100 per visit.

Sierra: no cost given.

API: assumed an annual maintenance cost equalling 10 percent of the processor cost (i.e., $2,790 x 0.10 = $279).

Table C-15. CAPITAL AND ANNUAL MAINTENANCE COST SUMMARY USING EPA MODEL PLANT PARAMETERS

SYSTEM (a) COST COMPONENT	BALANCE-IND		BALANCE-MANIFOLDED			HYB-1	HYB-2	ASSIST-1		ASSIST-2	
	EPA	SIERRA	EPA	SIERRA	API	EPA	SIERRA	EPA	API	EPA	SIERRA
CAPITAL RECOVERY COST (b)											
MODEL PLANT 1	677	1,214	722	1,073	948	735	1,312	1,629	980	1,642	1,950
MODEL PLANT 2	881	1,283	910	1,142	1,130	956	1,410	1,766	1,172	1,745	2,017
MODEL PLANT 3	1,564	1,672	1,592	1,531	1,799	1,714	1,927	2,378	1,881	2,217	2,399
MODEL PLANT 4	2,145	2,061	2,157	1,920	2,472	2,371	2,443	2,929	2,597	2,701	2,782
MODEL PLANT 5	3,229	2,740	3,214	2,607	3,832	3,603	3,385	3,964	4,040	3,349	3,456
MAINTENANCE COST											
MODEL PLANT 1	475	521	475	521	423	497	487	465	554	406	403
MODEL PLANT 2	620	677	617	677	549	646	633	575	636	498	524
MODEL PLANT 3	1,230	1,354	1,230	1,354	1,099	1,290	1,266	1,050	993	897	1,047
MODEL PLANT 4	1,850	2,031	1,850	2,031	1,648	1,940	1,898	1,530	1,350	1,290	1,571
MODEL PLANT 5	3,090	3,386	3,090	3,386	2,746	3,230	3,164	2,400	2,064	2,090	2,610
ANNUAL INSPECTION COST (c)											
MODEL PLANT 1	—	40	—	40	150	—	40	—	150	—	40
MODEL PLANT 2	—	52	—	52	150	—	52	—	150	—	52
MODEL PLANT 3	—	104	—	104	150	—	104	—	150	—	104
MODEL PLANT 4	—	156	—	156	150	—	156	—	150	—	156
MODEL PLANT 5	—	260	—	260	150	—	260	—	150	—	260
OTHER INDIRECT COSTS (d)											
MODEL PLANT 1	211	86	220	76	0	223	92	407	0	430	123
MODEL PLANT 2	274	90	285	80	0	290	98	446	0	468	134
MODEL PLANT 3	472	114	483	103	0	504	128	620	0	611	157
MODEL PLANT 4	630	138	634	127	0	678	159	770	0	750	180
MODEL PLANT 5	916	178	911	168	0	996	214	1,046	0	920	213
ANNUAL RECOVERY CREDITS (e)											
MODEL PLANT 1	129	90	129	90	78	129	90	65	41	65	90
MODEL PLANT 2	518	362	518	362	313	518	362	259	165	259	362
MODEL PLANT 3	906	633	906	633	547	906	633	453	288	453	633
MODEL PLANT 4	1,683	1,176	1,683	1,176	1,017	1,683	1,176	841	535	841	1,176
MODEL PLANT 5	4,790	3,347	4,790	3,347	2,894	4,790	3,347	2,395	1,523	2,395	3,347
ADDITIONAL CREDITS (f)											
MODEL PLANT 1	0	254	0	223	0	0	270	0	0	0	361
MODEL PLANT 2	0	266	0	235	0	0	287	0	0	0	393
MODEL PLANT 3	0	335	0	304	0	0	377	0	0	0	461
MODEL PLANT 4	0	405	0	374	0	0	468	0	0	0	529
MODEL PLANT 5	0	524	0	493	0	0	629	0	0	0	626
TOTAL ANNUALIZED COST											
MODEL PLANT 1	1,230	1,520	1,300	1,400	1,440	1,330	1,570	2,440	1,640	2,420	2,060
MODEL PLANT 2	1,260	1,480	1,290	1,350	1,520	1,370	1,540	2,530	1,790	2,450	1,970
MODEL PLANT 3	2,360	2,280	2,400	2,160	2,500	2,600	2,410	3,590	2,740	3,270	2,610
MODEL PLANT 4	2,940	2,810	2,960	2,680	3,250	3,310	3,010	4,390	3,560	3,910	2,980
MODEL PLANT 5	2,450	2,700	2,420	2,580	3,830	3,040	3,050	5,090	4,730	3,970	2,570
COST EFFECTIVENESS($/Mg CONTROLLED)											
MODEL PLANT 1	3,409	6,333	3,603	5,833	6,000	3,687	6,542	13,526	6,833	13,416	8,583
MODEL PLANT 2	873	1,542	894	1,406	1,583	949	1,604	3,506	1,865	3,395	2,052
MODEL PLANT 3	934	1,357	950	1,286	1,488	1,030	1,435	2,843	1,631	2,590	1,554
MODEL PLANT 4	627	901	631	859	1,042	706	965	1,872	1,141	1,667	955
MODEL PLANT 5	184	304	181	291	431	220	343	763	533	595	289

See next page for footnotes.

Footnotes for Table C-15

(a) Assist-1 = Hirt; Assist-2 = Hasstech; Hyb-1 = Healy; Hyb-2 = Red Jacket.

(b) Cost of Capital = (Capital Cost) $\times \dfrac{i\,(1 + i)^a}{(1 + i)^a - 1}$,

where: i = interest rate
a = equipment lifetime.

EPA: i = 10 percent
a = 8 years for dispenser and processing unit, and
35 years for piping
Sierra: i = 12 percent
a = 10 years for dispenser and processing unit, and
20 years for piping
API: i = 7.7 percent
a = 3 years for dispenser,
8 years for processing unit, and
15 years for piping.

(c) EPA: included in nationwide enforcement costs; therefore, not attributed on a per-facility basis.

Sierra: $16/nozzle.

API: $150/station.

(d) EPA: includes property tax (1%), insurance (1%), and administration (2%), equalling 4 percent of total capital cost.

Sierra: includes property tax equalling 1 percent of total capital cost.

(e) Balance and Hybrid:
EPA: Emission factors: Displacement = 1,552 mg/liter
Breathing loss = 120 mg/liter

Assuming 95% recovery of both displacement and breathing losses, recovery credit = (1,552 mg/liter) (0.95) + (120 mg/liter) (0.95) = 1,588 mg/liter.

Example of recovery credit for Model Plant 2 (=20,000 gallons = 75,700 liters):

1,588 mg/liter x 75,700 liters/month x kg/10^6 mg x liter/0.67 kg x 12 months/year x $0.24/liter = $518/year.

Assist-1 & Assist-2
Assuming 50% of the recovery credit associated with balance systems = [(1,552 mg/liter) (0.95) + (120 mg/liter) (0.95)] (0.50) = 794 mg/liter.

Footnotes for Table C-15 (concluded)

Example recovery credit: For Model Plant 2 (=20,000 gallons = 75,700 liters),
794 mg/liter x 75,700 liters/month x kg/10^6 mg x liter/0.67 kg x 12 months/year x \$0.24/liter = \$259/year.

Sierra: equals $\frac{\text{(throughput gal/mo)(12 mo/yr)(4.7 g/gal)(\$0.90/gal)}}{\text{2,806 g/gal}}$

API: equals \$0.0013/gal dispensed for balance systems and \$0.000686/gal dispensed for assist systems.

(f) EPA: none.

Sierra: includes investment tax credit (10%) and energy conservation tax credit (10%), equalling 20% of total capital cost amortized over 15 years at an interest rate of 12 percent.

API: none.

rates, emission factors, compiled recovery factors, equipment lifetimes, discounts, certification costs, tax credits, inspection fees, property tax, insurance, and administrative costs were changed to those used by EPA). Table C-16 shows the financial assumptions made in each analysis that were changed to those used by EPA. Table C-17 shows the Stage II capital costs and annual maintenance costs. Table C-18 shows the Stage II annualized costs. In both cases, EPA's costs generally are greater than API's and Sierra's.

Table C-16. FINANCIAL ASSUMPTIONS MADE BY EPA, SIERRA, AND API

	EPA[a]	Sierra	API
Interest Rate (%)	10	12	7.7
Dispenser Life (years)	8	10	3
Processor Life (years)	8	10	8
Piping Life (years)	35	20	15
Nozzle Discount (% discount)	0	10	0
Sales Tax (%)	b	5	0
Engineering Cost (% of total capital cost)	0	0	12
Certification Cost ($)	0	0	c
Tax Credit Life (years)	NA[d]	15	NA[d]
Insurance (% of capital cost)	1	0	0
Administration (% of capital cost)	2	0	0
Property Taxes (% of capital cost)	1	1	0
Inspection Cost[e]	0	16	150
RECOVERY CREDIT			
Balance and Hybrid ($/gal dispensed)	0.0022	0.0015	0.0013
Vacuum Assist ($/gal dispensed)	0.0011	0.0015	0.000686

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[a] All financial assumptions were changed to those used by EPA to calculate Table C-18 and Table C-19.

[b] Assumed that sales tax was included in total cost estimates received from vendors.

[c] Varies with service station (see Table C-3).

[d] NA - not applicable.

[e] Sierra - $/nozzle, API - $/station.

Table C-17. CAPITAL AND ANNUAL MAINTENANCE COST SUMMARY WITH ALL EPA INPUTS

SYSTEM (a)	BALANCE-IND		BALANCE-MANIFOLDED			HYB-1	HYB-2	ASSIST-1		ASSIST-2	
COST COMPONENT	EPA	SIERRA	EPA	SIERRA	API	EPA	SIERRA	EPA	API	EPA	SIERRA
DISPENSER CONVERSION ($/NOZZLE)											
NOZZLES (b)	197	198	197	198	84	215	161	178	114	124	124
MODIFICATION EQUIPMENT (c)	350	140	350	140	240	435	334	367	240	205	200
LABOR (d)	80	175	80	175	0	100	225	45	0	50	170
TOTAL DISPENSER COST	627	513	627	513	324	750	720	590	354	379	494
AUXILIARY EQUIPMENT ($/STATION)											
PROCESSING UNIT (e)	—	—	—	—	—	—	—	3,975	(f)	3,900	3,500
LABOR	—	—	—	—	—	—	—	1,400	(f)	1,200	2,000
TOTAL AUXILIARY COST	0	0	0	0	0	0	0	5,375	(f)	5,100	5,500
UNDERGROUND PIPING ($/STATION)											
MODEL PLANT 1	3,700	7,000	4,130	6,000	5,026	3,700	7,000	3,330	5,026	4,900	5,000
MODEL PLANT 2	4,810	7,000	5,090	6,000	5,603	4,810	7,000	3,850	5,603	5,380	5,000
MODEL PLANT 3	7,720	7,650	7,990	6,650	7,293	7,720	7,650	6,290	7,293	7,710	5,650
MODEL PLANT 4	9,640	8,300	9,750	7,300	8,994	9,650	8,300	8,140	8,994	10,150	6,300
MODEL PLANT 5	12,720	8,950	12,580	7,950	12,558	12,720	8,950	11,200	12,558	11,950	6,950
TOTAL EQUIPMENT & LABOR COST											
MODEL PLANT 1	5,270	8,283	5,700	7,283	5,836	5,580	8,800	10,180	10,473	10,950	11,735
MODEL PLANT 2	6,850	8,667	7,130	7,667	6,656	7,250	9,340	11,140	11,314	11,710	12,756
MODEL PLANT 3	11,800	10,985	12,070	9,985	9,399	12,600	12,330	15,500	14,202	15,270	15,011
MODEL PLANT 4	15,750	13,302	15,860	12,302	12,153	16,960	15,320	19,260	17,101	18,950	17,267
MODEL PLANT 5	22,910	17,286	22,770	16,286	17,823	24,910	20,650	26,150	23,070	23,210	20,478
ADDITIONAL CAPITAL COSTS (g)											
MODEL PLANT 1	0	0	0	0	0	0	0	0	0	0	0
MODEL PLANT 2	0	0	0	0	0	0	0	0	0	0	0
MODEL PLANT 3	0	0	0	0	0	0	0	0	0	0	0
MODEL PLANT 4	0	0	0	0	0	0	0	0	0	0	0
MODEL PLANT 5	0	0	0	0	0	0	0	0	0	0	0
TOTAL CAPITAL COST											
MODEL PLANT 1	5,270	8,283	5,700	7,283	5,840	5,580	8,800	10,180	10,470	10,950	11,735
MODEL PLANT 2	6,850	8,667	7,130	7,667	6,660	7,250	9,340	11,140	11,310	11,710	12,756
MODEL PLANT 3	11,800	10,985	12,070	9,985	9,400	12,600	12,330	15,500	14,200	15,270	15,011
MODEL PLANT 4	15,750	13,302	15,860	12,302	12,150	16,960	15,320	19,260	17,100	18,950	17,267
MODEL PLANT 5	22,910	17,286	22,770	16,286	17,820	24,910	20,650	26,150	23,070	23,210	20,478
DISPENSER MAINTENANCE ($/NZ/YR)											
NOZZLES (h)	65	74	65	74	83	73	56	56	58	32	37
HOSES (i)	43	6	43	6	51	43	6	43	51	43	6
BOOTS AND FACEPLATES (j)	82	132	82	132	35	83	135	47	0	47	120
BALL CHECK VALVE (k)	—	—	—	—	—	—	—	—	1	—	—
TOTAL DISPENSER MAINTENANCE COST	190	212	190	212	169	199	197	146	110	123	163
ADDITIONAL MAINTENANCE ($/STAT/YR)											
PROCESSING UNIT (l)	—	—	—	—	—	—	—	100	279	100	—
TOTAL ANNUAL MAINTENANCE COST											
MODEL PLANT 1	475	530	475	530	423	497	493	465	554	406	400
MODEL PLANT 2	620	689	617	689	549	646	640	575	636	498	530
MODEL PLANT 3	1,230	1,378	1,230	1,378	1,099	1,290	1,281	1,050	993	897	1,060
MODEL PLANT 4	1,850	2,067	1,850	2,067	1,648	1,940	1,921	1,530	1,350	1,290	1,589
MODEL PLANT 5	3,090	3,445	3,090	3,445	2,746	3,230	3,281	2,400	2,064	2,090	2,649

e next page for footnotes.

Footnotes for Table C-17

(a) Hyb-1 = Healy; Hyb-2 = Red Jacket; Assist-1 = Hirt; Assist-2 = Hasstech.

(b) API calculates incremental cost between standard nozzle ($60) and vapor recovery nozzle ($144 for balance nozzle and $174 for assist nozzle).

(c) Balance-Ind

EPA: includes cost of overhead hose retractor system, applicable swivels, flow limiter, hanger kit, and the incremental cost between a standard liquid hose and a liquid/vapor recovery hose system.

Sierra: includes cost of anti-recirculation valve, flow limiter, hose swivels, new liquid hose and vapor recovery hose, and hanger kit.

Balance-Manifolded

EPA: same as Balance-Ind for EPA.
Sierra: same as Balance-Ind for Sierra.
API: includes swivels, hoses, and retractors.

Hyb-1

EPA: includes cost of Model 100 jet pump, Model CX-6 adapter, installation kit, Model S swivel, Model 143 control valve, and incremental cost between standard liquid hose and Model CX hose.

Hyb-2

Sierra: includes aspirator, new liquid hose and vapor recovery hose, hose swivels, and hanger kit.

Assist-1

EPA: same as Balance-Ind for EPA plus cost of ball check valve.
API: same as Balance-Manifolded.

Assist-2

EPA: cost obtained from Hasstech, Inc. (see Appendix B); no specific component breakdown given.
Sierra: includes cost of check valve, flame arrestor, vapor hose, and hanger kit.

(d) Sierra's labor cost for each system includes the cost of an overhead hose retractor system.

(e) Cost includes collection unit (blower, turbine, etc.), control panel, processor, and pressure/vacuum valve for manifolded vent risers.

(f) Total processor costs estimated by API are:

Model plant 1: $4,563*
Model plant 2: $4,563
Model plant 3: $4,612*
Model plant 4: $4,714
Model plant 5: $4,768

*Estimated by EPA from data presented by API.

Footnotes for Table C-17 (continued)

(g) Sierra: an average discount of 10% on the cost of nozzles and a 5% sales tax on the "Total Equipment and Labor Cost" is applied (e.g., for a balance-individual system, Model Plant 2; additional cost = - ($198/nozzle x 0.1 nozzle discount x 3 nozzles/model plant x 1.05 sales tax) + ($8,539 total equipment and labor costs x .05 sales tax) = -($20 x 3 x 1.05) + ($8,539 x (1.05 - 1) = - 63 + 427 = $364.

API: a 12% engineering cost on "Total Equipment and Labor Cost" and an installation fee (see Table C-3) is applied (e.g., for a balance manifolded system, Model Plant 3; additional cost = ($9,237 equipment and labor cost) x (0.12 engineering cost) + ($452 installation fee) = $1,560.

EPA: engineering, inspection costs, and sales tax were not included in the EPA analysis.

(h) EPA: replace every 2 years with new nozzle (same lifetime as standard nozzle); therefore, annual cost equals half the incremental cost between standard ($50) and vapor recovery nozzles. Multiproduct dispenser nozzle maintenance costs considered half that of conventional nozzles.

Sierra: replace every 2 years with new nozzle (same lifetime as standard nozzle); therefore, annual cost equals half the incremental cost between standard ($50) and vapor recovery nozzles. The 10% nozzle discount and 5% sales tax are also included in this price (e.g., balance-individual nozzle replacement = [($198/nozzle x 0.9 discount) - $50/conventional nozzle] x 1.05 sales tax x 1/2 replacement per year = [(178 - 50) x 1.05] /2 = $67/nozzle.

API: replace nozzles every year with rebuilt nozzle; cost presented includes deduction for standard rebuilt nozzle ($17).

(i) EPA: replace every 2 years (same lifetime as liquid hose on standard dispenser); therefore, annual cost equals half the incremental cost between standard liquid hose ($24) and coaxial liquid/vapor recovery hose system.

Sierra: replace vapor hose ($12) every 2 years.

API: annual equipment costs (including retractors) average $30 and labor averages $21 per year.

(j) Balance-Ind

EPA: replace three times per year; parts cost $19 per replacement, and 20 minutes labor per replacement at $25 per hour.

Footnotes for Table C-17 (concluded)

Sierra: replace three times per year, parts cost $19 per replacement, and 1 hour labor per replacement at $25 per hour.

Balance-Manifolded

EPA: replace three times per year, parts cost $19 per replacement, and 20 minutes labor per replacement at $25 per hour.

Sierra: replace three times per year, parts cost $19 per replacement, and 1 hour labor per replacement at $25 per hour.

API: replace two times per year.

Hyb-1

EPA: replace two times per year, parts cost $33 per replacement, and 20 minutes labor per replacement at $25 per hour.

Hyb-2

Sierra: replace three times per year, parts cost $20 per replacement, and 1 hour labor per replacement at $25 per hour.

Assist-1

EPA: replace two times per year, parts cost $15 per replacement, and 20 minutes labor per replacement at $25 per hour.

API: replace two times per year.

Assist-2

EPA: replace two times per year, parts cost $15 per replacement, and 20 minutes labor per replacement at $25 per hour.

Sierra: replace three times per year, parts cost $15 per replacement, and 1 hour labor per replacement at $25 per hour.

(k) API assumed an annual maintenance cost equalling 5 percent of component cost (i.e., $17 x 0.05 = $1).

(l) EPA: maintenance time per year at $100 per visit.

Sierra: no cost given.

API: assumed an annual maintenance cost equalling 10 percent of the processor cost (i.e., $2,790 x 0.10 = $279).

Table C-18. STAGE II ANNUAL COST SUMMARY WITH ALL EPA INPUTS

SYSTEM (a)	BALANCE-IND		BALANCE-MANIFOLDED			HYB-1	HYB-2	ASSIST-1		ASSIST-2	
COST COMPONENT	EPA	SIERRA	EPA	SIERRA	API	EPA	SIERRA	EPA	API	EPA	SIERRA
CAPITAL RECOVERY COST (b)											
MODEL PLANT 1	677	966	722	863	673	735	1,063	1,629	687	1,642	1,723
MODEL PLANT 2	881	1,038	910	935	778	956	1,164	1,766	796	1,745	1,850
MODEL PLANT 3	1,564	1,418	1,592	1,315	1,151	1,714	1,670	2,378	1,187	2,217	2,161
MODEL PLANT 4	2,145	1,798	2,157	1,694	1,525	2,371	2,176	2,929	1,579	2,701	2,530
MODEL PLANT 5	3,229	2,491	3,214	2,387	2,289	3,603	3,121	3,964	2,379	3,349	3,199
MAINTENANCE COST											
MODEL PLANT 1	475	530	475	530	423	497	493	465	554	406	408
MODEL PLANT 2	620	689	617	689	549	646	640	575	636	498	530
MODEL PLANT 3	1,230	1,378	1,230	1,378	1,099	1,290	1,281	1,050	993	897	1,060
MODEL PLANT 4	1,850	2,067	1,850	2,067	1,648	1,940	1,921	1,530	1,350	1,290	1,589
MODEL PLANT 5	3,090	3,445	3,090	3,445	2,746	3,230	3,201	2,480	2,064	2,090	2,649
ANNUAL INSPECTION COST (c)											
MODEL PLANT 1	—	40	—	40	150	—	40	—	150	—	40
MODEL PLANT 2	—	52	—	52	150	—	52	—	150	—	52
MODEL PLANT 3	—	104	—	104	150	—	104	—	150	—	104
MODEL PLANT 4	—	156	—	156	150	—	156	—	150	—	156
MODEL PLANT 5	—	260	—	260	150	—	260	—	150	—	260
OTHER INDIRECT COSTS (d)											
MODEL PLANT 1	211	331	228	291	234	223	352	407	419	438	469
MODEL PLANT 2	274	347	285	307	266	290	374	446	452	468	510
MODEL PLANT 3	472	439	483	399	376	504	493	620	568	611	600
MODEL PLANT 4	630	532	634	492	486	678	613	770	684	758	691
MODEL PLANT 5	916	691	911	651	713	996	826	1,046	923	928	819
ANNUAL RECOVERY CREDITS (e)											
MODEL PLANT 1	129	129	129	129	129	129	129	65	65	65	65
MODEL PLANT 2	518	518	518	518	518	518	518	259	259	259	259
MODEL PLANT 3	906	906	906	906	906	906	906	453	453	453	453
MODEL PLANT 4	1,683	1,683	1,683	1,683	1,683	1,683	1,683	841	841	841	841
MODEL PLANT 5	4,790	4,790	4,790	4,790	4,790	4,790	4,790	2,395	2,395	2,395	2,395
ADDITIONAL CREDITS (f)											
MODEL PLANT 1	0	0	0	0	0	0	0	0	0	0	0
MODEL PLANT 2	0	0	0	0	0	0	0	0	0	0	0
MODEL PLANT 3	0	0	0	0	0	0	0	0	0	0	0
MODEL PLANT 4	0	0	0	0	0	0	0	0	0	0	0
MODEL PLANT 5	0	0	0	0	0	0	0	0	0	0	0
TOTAL ANNUALIZED COST											
MODEL PLANT 1	1,230	1,740	1,300	1,590	1,350	1,330	1,820	2,440	1,740	2,420	2,580
MODEL PLANT 2	1,260	1,610	1,290	1,460	1,230	1,370	1,710	2,530	1,780	2,450	2,680
MODEL PLANT 3	2,360	2,430	2,400	2,290	1,870	2,600	2,640	3,590	2,440	3,270	3,470
MODEL PLANT 4	2,940	2,870	2,960	2,730	2,130	3,310	3,180	4,390	2,920	3,910	4,120
MODEL PLANT 5	2,450	2,100	2,420	1,950	1,110	3,040	2,620	5,090	3,120	3,970	4,530
COST EFFECTIVENESS($/Mg CONTROLLED)											
MODEL PLANT 1	3,409	4,823	3,603	4,407	3,742	3,687	5,045	13,526	9,646	13,416	14,303
MODEL PLANT 2	873	1,116	894	1,012	852	949	1,185	3,506	2,467	3,395	3,714
MODEL PLANT 3	934	962	950	907	740	1,030	1,045	2,843	1,932	2,590	2,748
MODEL PLANT 4	627	612	631	582	454	706	678	1,872	1,245	1,667	1,757
MODEL PLANT 5	104	157	181	146	83	228	196	763	467	595	679

See next page for footnotes.

Footnotes for Table C-18

(a) Assist-1 = Hirt; Assist-2 = Hasstech; Hyb-1 = Healy; Hyb-2 = Red Jacket.

(b) Cost of Capital = (Capital Cost) $\times \frac{i\,(1 + i)^a}{(1 + i)^a - 1}$,

where: i = interest rate
a = equipment lifetime.

EPA: i = 10 percent
a = 8 years for dispenser and processing unit, and
35 years for piping

Sierra: i = 12 percent
a = 10 years for dispenser and processing unit, and
20 years for piping

API: i = 7.7 percent
a = 3 years for dispenser,
8 years for processing unit, and
15 years for piping.

(c) EPA: included in nationwide enforcement costs; therefore, not attributed on a per-facility basis.

Sierra: $16/nozzle.

API: $150/station.

(d) EPA: includes property tax (1%), insurance (1%), and administration (2%), equalling 4 percent of total capital cost.

Sierra: includes property tax equalling 1 percent of total capital cost.

(e) Balance and Hybrid:

EPA: Emission factors: Displacement = 1,552 mg/liter
Emptying loss = 120 mg/liter

Assuming 95% recovery of both displacement and emptying losses, recovery credit = (1,552 mg/liter) (0.95) + (120 mg/liter) (0.95) = 1,588 mg/liter.

Example of recovery credit for Model Plant 2 (=20,000 gallons = 75,700 liters):

1,588 mg/liter x 75,700 liters/month x kg/10^6 mg x liter/0.67 kg x 12 months/year x $0.24/liter = $518/year

Assist-1 & Assist-2

Assuming 50% recovery of displacement and 95% of emptying losses, recovery factor = [(1,552 mg/liter) (0.95) + (120 mg/liter) (0.95)] = 794 mg/liter.

Footnotes for Table C-18 (concluded)

Example recovery credit: For Model plant 2 (=20,000 gallons = 75,700 liters)

794 mg/liter x 7,571 liters/month x kg/10^6 mg x
12 months/year x \$0.24/liter = \$259/year.

Sierra: equals $$\frac{\text{(throughput gal/mo)(12 mo/yr)(4.7 g/gal)(\$0.90/gal)}}{\text{2,806 g/gal}}$$

API: equals \$0.0013/gal dispensed for balance systems and \$0.000686/gal dispensed for assist systems.

(f) EPA: none.

Sierra: includes investment tax credit (10%) and energy conservation tax credit (10%), equalling 20% of total capital cost amortized over 15 years at an interest rate of 12 percent.

API: none.

C.5 REFERENCES

I-D-42 Letter from Panzer, J., Exxon Research and Engineering Company, Linden, New Jersey, to Eldridge, K., Pacific Environmental Services, Inc. January 8, 1985.

I-E-30 Telecon. Eldridge, K., Pacific Environmental Services, Inc., with Panzer, J., Exxon Research and Engineering Company, Linden, New Jersey. November 8, 1984.

I-F-98 "Cost Comparisons for Stage II and On-Board Control of Refueling Emissions." Prepared by the American Petroleum Institute. Washington, D.C. January 1984.

I-F-100 "Refueling Emissions Control - Onboard vs. Service Station Controls." Prepared for Ford Motor Company by Sierra Research Corporation. Sacramento, California. March 1984.

APPENDIX D

SERVICE STATION PROJECTIONS

APPENDIX D
SERVICE STATION PROJECTIONS

D.1 INTRODUCTION

Several comments (I-H-114, I-H-127) were received concerning the assumption, made in EPA's July 1984 analysis, that the number of service stations would stay constant throughout the period of the analysis. These commenters remarked that the number of service stations not only has decreased since the time of the 1984 analysis (1982 base year), but is expected to continue to decrease. Such a decrease would especially be expected with the continued decrease in projected gasoline consumption. In addition, the commenters suggested that the shift from smaller to larger facilities would also continue. Studies conducted by Sierra Research Corporation (I-F-100, I-H-114) for Ford Motor Company, and submitted to EPA for review, projected both a decreasing number of stations and a shift in station size. The result of the assumptions made by Sierra Research was a decreased cost for Stage II strategies relative to EPA's estimates, since fewer stations were projected to exist in the future and, hence, to require control. The EPA was aware of the continued decline in the service station population when the July 1984 analysis was completed; however, a suitable methodology could not be devised to reflect this decrease. The Agency has now adopted a methodology similar to that used by Sierra Research, with some modifications. A computer model was developed to project the decreasing number of (and, in some cases, the decreasing throughputs at) service stations through the year 2020. The purpose of Appendix D is to discuss the methodology used in EPA's service station projections.

D.2 BASIC METHODOLOGY

In general, the service station projection model made three basic adjustments to Sierra's method. The first adjustment was to reduce the number of public facilities based on the reduction in gasoline consumption (less gasoline to pump = fewer stations). The second adjustment was for private facilities. The Agency felt that a decline in consumption would not necessarily result in a decline in private fleet operations, but rather just a decline in each facility's throughput. Therefore, for private facilities, the facility throughput was adjusted proportional to the decline in gasoline consumption. (It should be noted that the model also has the capability to adjust for increases in gasoline consumption.) The third adjustment was to account for the trend toward larger, more efficient stations. The model estimates the closure of existing small facilities and the building of new larger facilities.

D.2.1 Number of Facilities

Several commenters questioned the number of facilities assumed in the July 1984 analysis (210,900 public stations and 210,300 private stations for a 1982 base year). The EPA reviewed available data and revised the public station total to 190,000 to reflect the latest estimate for the new 1984 base year (I-F-124). No data were available to adjust the private facility total to reflect 1984, so this value remained at 210,300.

Facility projections used in the EPA model apply only to public service stations. The number of public stations was decreased or increased in proportion to the projected decrease or increase in nationwide throughput (based on the gasoline consumption projections discussed in Section 2.3.2 of Chapter 2). Specifically, the number of public service stations was determined by uniformly decreasing the throughput for each existing facility type (model plant size range and ownership classification) by the same percentage as the projected decrease in nationwide consumption. The throughput assigned each facility type was then divided by the corresponding representative model plant throughput.

The number of private stations was considered to stay constant with time, since the market pressures associated with decreasing consumption and shifts to more efficient stations do not apply to private facilities. In the model, however, throughput at the private facilities was decreased in proportion to the decrease in total gasoline consumption to reflect the impact of decreased overall consumption caused by increased fuel economy. The throughput adjustment at private facilities and the industry trend toward larger, more efficient public facilities are discussed in more detail in Section D.2.2.

D.2.2 Size Distribution of Facilities

Distribution of public stations was shifted from smaller model plants to larger model plants to reflect current trends toward larger facilities. The EPA model accomplished this by removing facilities from the smaller model plant totals and adding facilities to the larger model plant totals; the total throughput of the new facilities was assumed equivalent to the total throughput of the closed facilities. Table D-1 summarized the projection of new facilities used in the analysis. Throughput to be shifted from small facilities in a given year was assumed to be 50 percent of the throughput decrease from the previous year for existing (pre-1985) model plant numbers 1, 2, and 3 (Sierra assumed 50 percent of the decrease from all facilities in only model plant numbers 2 and 3). This total shifted throughput was distributed as new public facilities in the following manner: 20 percent was assumed to be apportioned to each of model plants 2 and 3 (40 percent total) in order to reflect new convenience stores, and 30 percent of the total was assumed to be apportioned to each of model plant numbers 4 and 5 (60 percent total) in order to reflect the shift toward larger facilities (Sierra assumed all of the shifted throughput would go to model plant 5). Redistributed facilities were assumed to be new or totally reconstructed stations (implying no difference in cost between three one-island expansions and one three-island new station). After the year 2000, no new facilities were projected since the gasoline consumption was assumed constant from 2000 to 2020, and new facility projections were based on changes in consumption.

As a check, the model compares the total consumption in each year (from the fuel consumption model) with the consumption obtained by multiplying the number of facilities in each model plant size by their respective model plant throughput. In no case did the yearly consumptions differ by more than 3 percent. Thus, unlike the Sierra model, the model used in the EPA reanalysis keeps the total contributions of the individual model plants roughly equal to the projected total national consumption in each year. Table D-2 indicates the results of the service station projection model. Shown are the total number of service stations in each year, the total number of public stations in each year, and the number of public stations for each year for each model plant size.

Table D-1. SUMMARY OF NEW FACILITY PROJECTIONS FROM THE SERVICE STATION PROJECTION MODEL

YEAR	TOTAL OF NEW FACILITIES IN EACH YEAR	NEW PUBLIC FACILITIES BY MODEL PLANT				
		MP1	MP2	MP3	MP4	MP5
1984	0	0	0	0	0	0
1985	716	0	326	187	150	53
1986	658	0	300	170	139	49
1987	589	0	268	154	124	43
1988	525	0	239	137	110	39
1989	454	0	207	118	96	33
1990	405	0	185	105	85	30
1991	405	0	184	106	85	30
1992	405	0	185	105	85	30
1993	405	0	185	105	85	30
1994	392	0	178	102	83	29
1995	405	0	184	106	85	30
1996	343	0	157	89	72	25
1997	277	0	126	72	58	21
1998	224	0	102	59	47	16
1999	183	0	83	48	38	14
2000	134	0	61	34	29	10
2001	0	0	0	0	0	0
2002	0	0	0	0	0	0
2003	0	0	0	0	0	0
2004	0	0	0	0	0	0
2005	0	0	0	0	0	0
2006	0	0	0	0	0	0
2007	0	0	0	0	0	0
2008	0	0	0	0	0	0
2009	0	0	0	0	0	0
2010	0	0	0	0	0	0
2011	0	0	0	0	0	0
2012	0	0	0	0	0	0
2013	0	0	0	0	0	0
2014	0	0	0	0	0	0
2015	0	0	0	0	0	0
2016	0	0	0	0	0	0
2017	0	0	0	0	0	0
2018	0	0	0	0	0	0
2019	0	0	0	0	0	0
2020	0	0	0	0	0	0

Table D-2. RESULTS OF SERVICE STATION FACILITY PROJECTION MODEL

Year	Number of Facilities						
	Total of All Facilities[a]	Total of Public Facilities	Public Facilities by Model Plant				
			MP1[b]	MP2	MP3	MP4	MP5
1984	400,250	190,000	49,400	57,000	50,350	26,600	6,650
1985	395,489	185,239	47,888	55,581	48,996	26,207	6,567
1986	391,129	180,879	46,502	54,282	47,754	25,349	6,492
1987	387,206	176,956	45,256	53,113	46,638	25,526	6,423
1988	383,723	173,473	44,150	52,075	45,646	25,239	6,363
1989	380,699	170,449	43,189	51,174	44,786	24,990	6,310
1990	377,998	167,748	42,332	50,370	44,017	24,767	6,262
1991	375,319	165,069	41,481	49,571	43,255	24,546	6,216
1992	372,622	162,372	40,624	48,768	42,487	24,324	6,169
1993	369,931	159,681	39,769	47,966	41,721	24,102	6,123
1994	367,335	157,085	38,944	47,192	40,982	23,889	6,078
1995	364,647	154,397	38,090	46,391	40,218	23,667	6,031
1996	362,362	152,112	37,365	45,711	39,567	23,478	5,991
1997	360,529	150,279	36,782	45,165	39,045	23,320	5,959
1998	359,028	148,778	36,305	44,717	38,619	23,204	5,933
1999	357,821	147,571	35,922	44,357	38,275	23,104	5,913
2000	356,938	146,688	35,641	44,095	38,024	23,031	5,897
2001	356,938	146,688	35,641	44,095	38,024	23,031	5,897
2002	356,933	146,683	35,640	44,093	38,022	23,031	5,897
2003	356,933	146,683	35,640	44,093	38,022	23,031	5,897
2004	356,933	146,683	35,640	44,093	38,022	23,031	5,897
2005	356,933	146,683	35,640	44,093	38,022	23,031	5,897
2006	356,933	146,683	35,640	44,093	38,022	23,031	5,897
2007	356,933	146,683	35,640	44,093	38,022	23,031	5,897
2008	356,930	146,680	35,639	44,092	38,021	23,031	5,897
2009	356,930	146,680	35,639	44,092	38,021	23,031	5,897
2010	356,930	146,680	35,639	44,092	38,021	23,031	5,897
2011	356,930	146,680	35,639	44,092	38,021	23,031	5,897
2012	356,926	146,676	35,637	44,090	38,021	23,031	5,897
2013	356,926	146,676	35,637	44,090	38,021	23,031	5,897
2014	356,926	146,676	35,637	44,090	38,021	23,031	5,897
2015	356,926	146,676	35,637	44,090	38,021	23,031	5,897
2016	356,926	146,676	35,637	44,090	38,021	23,031	5,897
2017	356,926	146,676	35,637	44,090	38,021	23,031	5,897
2018	356,926	146,676	35,637	44,090	38,021	23,031	5,897
2019	356,926	146,676	35,637	44,090	38,021	23,031	5,897
2020	356,926	146,676	35,637	44,090	38,021	23,031	5,897

[a] Estimate includes all public and private gasoline dispensing facilities. Does not include farms and other small operations for refueling agricultural-related equipment.

[b] MP1 = Model Plant 1. Model plants described in Table 2-3.

No changes were made to the proportion of public stations assumed to be non-independent versus independent. For private stations, the number of facilities in each model plant was assumed to remain constant; however, the representative model plant throughput decreased with time in proportion to the nationwide consumption decrease. This reflects the presumed situation of private concerns (government, commercial, industrial, etc.) keeping their own service stations open, but using less gasoline due to increased fuel economy and other conservation measures.

Several commenters felt that the Model Plant 1 throughput (5,000 gallons/month) was too high to represent the private sector, which makes up the majority of the facilities in Model Plant 1 (approximately 80 percent), and that 2,000 gallons/month would be more representative. The EPA reanalyzed the existing data and agreed that 2,000 gallons/month would better represent the throughput at a private facility, but would be too small, given the installed equipment (2 nozzles), for a public facility. Therefore, in the new analysis, Model Plant 1 was divided into a private facility (2,000 gallons/month) and a public facility (6,000 gallons/month). Both are considered Model Plant 1's because both facility types have the identical physical equipment and layout. The size distribution of the remainder of the service station model plants remained the same as in the July 1984 analysis (see Table D-3).

The above discussion summarizes EPA's service station projection methodology as it was used in the reanalysis. Given the number and throughput of existing and new service station types, control option costs could be determined, as well as the throughput exempted from control for purposes of calculating emission and incidence reduction. The use of the facility projections model affected the service station costing because: (1) the number of facilities changed with time (affecting the costs of retrofit, new, and replacement Stage II installations), (2) the closing of small facilities and opening of large facilities changed the facility size distribution with time (this also affected the evaluation of exempting certain size stations), and (3) the tracking of each type of facility in each year allowed for the inclusion of a cost differential between new and existing facilities.

Table D-3. ESTIMATED 1984 SERVICE STATION SIZE DISTRIBUTION

Model Plant No.		1a	1b	2	3	4	5	Totals
Average Throughput 10^3 l/mo		7.6	23	76	132	246	700	-
(10^3 gal/mo)		(2)	(6)	(20)	(35)	(65)	(185)	
No. of	Single Dispensers	2	2	3	6	9	15	-
Nozzles	Multidispensers	4	4	4	8	12	20	-
"Public" Service Stations								
- Independents		-	8,900	17,700	22,500	10,400	2,600	
- Nonindependents		-	40,500	39,300	27,900	16,200	4,000	
- Total		-	49,400	57,000	50,400	26,600	6,600	190,000
- Percent		-	26	30	26.5	14	3.5	100.0
"Private" Service Stations								
Population		189,200	-	8,600	7,400	4,200	800	210,300
Percent		90	-	4.1	3.5	2.0	0.5	100.0
Total Facilities								
Population		189,200	49,400	65,600	57,800	30,800	7,400	400,200
Percent		47	12	16	14	8	2	100.0
Throughput								
(% of total consumption)		5.1	4.0	17.8	27.4	27.1	18.5	100.0

D.3 REFERENCES

I-F-100 "Refueling Emissions Control - Onboard vs. Service Station Controls." Prepared for Ford Motor Company by Sierra Research Corporation. Sacramento, California. March 1984.

I-F-124 "Service Station Shakeout Continues," 1984 National Petroleum News Factbook Issue. 76 (6a):103.

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APPENDIX E

REANALYSIS OF ECONOMIC IMPACTS

APPENDIX E

REANALYSIS OF ECONOMIC IMPACTS

E.1 INTRODUCTION

Chapter 8 of "Evaluation of Air Pollution Regulatory Strategies for Gasoline Marketing Industry" (EPA-450/3-84-012a) provides an analysis of potential economic impacts associated with various regulatory strategies. Impact estimates, expressed in mid-1982 dollars, were derived from previously available facility cost estimates updated to mid-1982, and 1982 facility populations. Only the onboard control analysis included facility (vehicle) projections.

When the analysis was published in July, 1984, some commenters stated that a number of the costs were out-of-date and/or underestimated. Several commenters remarked that EPA's failure to project service station populations resulted in overestimated Stage II impacts. Others criticized the exemption option, which treats independent and nonindependent facilities differently. In order to respond to comments concerning costs, the principal cost figures were reevaluated, some cost estimates were revised, and all costs were updated to third-quarter 1984 dollars. The number of service stations in each size class was projected for each year of the analysis. Additionally, EPA considered two alternative exemption options.

This reanalysis, which incorporates the aforementioned revisions, provides a summary of some of the economic impacts associated with various regulatory strategies: Section E.2 presents estimates of price impacts (price increases stemming from increased costs) and quantity impacts (consumption reductions attributable to price increases) for several nationwide and nonattainment area strategies; Section E.3 provides estimates of service station closures associated with these strategies; and Section E.4 examines a variety of financial ratios for various size gasoline marketing firms in SIC 5541, Gasoline Service Stations.

E.2 PRICE AND QUANTITY IMPACTS

Gasoline and/or vehicle price increases are associated with a variety of regulatory strategies. Gasoline price increases are estimated under two nationwide regulatory strategies (Stage I or Stage II control) and two nonattainment area strategies (Stage II control for 61 areas, alone or in combination with onboard control). Nationwide and nonattainment area strategies result in nationwide and regional price increases, respectively. Vehicle price increases are associated with any strategy including onboard and/or evaporative control.

Estimated price increases per liter of gasoline are based on average unit cost increases attributed to the regulatory strategies. Average unit cost increase is calculated by dividing the annual equivalent of the 1988 NPV of regulation cost (excluding enforcement expenditures) by average annual gasoline consumption in the control area over the period of analysis. Nationwide impact estimates are based on average annual gasoline consumption of 286.5 billion liters/year (75.6 billion gallons/year), while estimates for 61 nonattainment areas assume 100.3 billion liters/year (26.5 billion gallons/year). Vehicle price increases are based on model year-specific unit cost increases for light motor vehicles (LMVs) and light duty trucks (LDTs).

Reductions in gasoline and/or vehicle consumption attributed to gasoline and/or vehicle price increases are also estimated for each regulatory strategy. Average reductions in gasoline consumption are based on average unit cost increases, a base gasoline price of 31.7¢/liter (120¢/gallon), average annual consumption in the control area over the period, and a gasoline price elasticity of -0.55. Estimated reductions in vehicle consumption attributed to vehicle price increases are based on vehicle cost increases, base vehicle prices of $9,334/LMV and $13,795/LDT, projected vehicle consumption for the relevant model year periods, and a vehicle price elasticity of -1.11.

As shown in Table E-1, estimated gasoline price increases attributed to nationwide regulatory strategies range from 0.03 ¢/liter for Stage I control with exemptions to 0.16 ¢/liter for Stage II control with no exemptions. These increases represent from 0.1 to 0.5 percent of the base gasoline price. Estimated regional price increases under Stage II control in 61 nonattainment areas are similar to estimated national price increases under nationwide Stage II control. (Larger ranges reflect a wider variety of phase-in assumptions.)

For nationwide strategies, estimated reductions in gasoline consumption, also shown in Table E-1, range from 120 million liters/year for Stage I control

TABLE E-1. AVERAGE UNIT COST AND QUANTITY EFFECTS FOR GASOLINE UNDER SELECTED REGULATORY STRATEGIES[a]

Regulatory strategy	Option[b]	Unit cost increase of gasoline[c] (1984 ¢/liter)	Average reduction in gasoline consumption (10^6 liters/year)
Stage I--nationwide	A,A^1	0.03	120
Stage II--nationwide[d]	A	0.06-0.06	290-320
	A^1	0.07-0.08	350-410
	A^{11}	0.11-0.13	560-640
	B	0.14-0.16	710-820
Stage II--61 non-attainment areas[d]	A	0.06-0.09	100-150
	A^1	0.07-0.11	130-200
	A^{11}	0.11-0.18	200-310
	B	0.14-0.22	250-390
Stage II and onboard--61 attainment areas[d]	A	0.05-0.07	80-130
	A^1	0.06-0.10	100-160
	A^{11}	0.08-0.14	150-250
	B	0.10-0.17	180-290

[a] Average unit cost is aggregate annualized cost (excluding enforcement expenditures) divided by average annual gasoline consumption. Reductions in consumption attributed to regulation are based on a gasoline price elasticity of -0.55.

[b] Options A, A^1, and A^{11} include throughput-based size exemptions for bulk plants and service stations. Under Stage I control, Options A and A^1 exempt bulk plants with throughputs <10,000 gal/mo from outgoing balance controls and service stations with throughputs <10,000 gal/mo from all controls. Under Stage II control, Option A exempts independent and non-independent service stations with <50,000 gal/mo and <10,000 gal/mo throughputs, respectively. Options A^1 and A^{11} exempt all stations with throughputs <10,000 gal/mo and <2,000 gal/mo, respectively. Option B includes no exemptions.

[c] To convert to ¢/gal, multiply by 3.79.

[d] Ranges are based on cost ranges provided in Chapter 3, Tables 3-6, 3-12, and 3-13 (less enforcement expenditures).

with exemptions to 820 million liters/year for Stage II control with no exemptions. These reductions represent from 0.04 to 0.29 percent of average national annual gasoline consumption over the period. Estimated reductions in gasoline consumption associated with Stage II control in 61 nonattainment areas range from 80 to 390 million liters/year, representing from 0.03 to 0.14 percent of average national annual gasoline consumption. While nationwide Stage II control and Stage II control in nonattainment areas result in similar price increases, the associated reductions in consumption differ. Stage II control in nonattainment areas results in smaller reductions in consumption because estimated price increases apply only in those areas.

Table E-2 presents unit cost (price) and quantity effects for evaporative control applied to new vehicles in two model year periods (1990 - 1994 and 1995 - 2020) and for onboard and evaporative control of new vehicles in three model year periods (1990 - 1994, 1995 - 1999, and 2000 - 2020). For evaporative control, estimated vehicle price increases and accompanying reductions in consumption represent, at most, 0.03 percent of base vehicle price and production. Under onboard and evaporative control, vehicle prices are predicted to increase by about 0.2 percent, inducing vehicle consumption to decline by 0.2 percent.

Although the impacts presented in Table E-2 are small, they may be overstated. Each vehicle control strategy generates recovery credits through increased fuel efficiency and, therefore, the user cost of each control is less than the estimated vehicle price increase. User costs for these vehicle controls have been estimated assuming the above vehicle price increases, recovery estimates from the most recent vehicle control analysis, vehicle miles traveled estimates from Appendix C of "Evaluation of Air Pollution Regulatory Strategies for Gasoline Marketing Industry (EPA450/3-84-012a), a gasoline price of 31.7¢/liter, and a 10 percent discount rate. These estimates indicate that evaporative control on a new vehicle would pay for itself in three to four years. The combination of onboard and evaporative control would not pay for itself over the vehicle life. However, the net cost of control to the purchaser of a 1990 LMV with a 10-year life is about $9.20, or less than 50 percent of the 1990 LMV price increase. In fact, for all model years and vehicle types, the user cost of onboard and evaporative control over 10 years represents less than 50 percent of the vehicle price increase.

If vehicle purchasers are aware of the cost savings as well as the price increases associated with these vehicle controls, the consumption reductions presented in Table E-2 are probably overestimated. The degree of overestimation depends on the discount rate and lifetime or payback period considered appropriate for these types of consumer decisions. However, if vehicle purchasers do not have sufficient information to recognize and estimate cost savings, estimated consumption reductions do not overstate consumer response to estimated vehicle price increases.

E.3 MARKET ANALYSIS: CLOSURES

Reductions in gasoline consumption attributed to increased gasoline prices will result in the closure of some gasoline marketing operations, especially retail facilities. This section provides estimates of the numbers of service station closures that might occur as a result of Stage I or Stage II control on a national basis, or Stage II control in 61 nonattainment areas.

The estimates following are rough for these reasons: (1) There is no accepted methodology for projecting closures resulting from increased costs of control; (2) gasoline is not sold in a national market where each facility is in competition with all other facilities. Rather, gasoline is sold in local markets that vary in size; and (3) it is not sufficient to assume that closures will be restricted to facilities that have the highest per unit production and/or control costs (smaller facilities). Some smaller, higher cost facilities are, and will continue to be, optimal for the smaller markets they serve.

E.3.1 Methodology

Because there is no standard method for estimating closures, this market analysis selects and employs two different methodologies and compares the results. The first methodology, Method I, uses the average unit cost increases and gasoline consumption reductions presented in the price and quantity impacts analysis. Under Method I, projected reductions in gasoline consumption are assumed to be shared by all facility size classes in accordance with a base year public station throughput distribution. The base year (2004) is midway through the period of analysis because the throughput distribution for the initial year (1990) does not adequately reflect existing industry trends toward larger facilities. Facility closures in each model plant category are estimated by dividing the consumption reduction allotted to that category by model plant size. The total number of closures is the sum of closures in each model plant class.

TABLE E-2. AVERAGE UNIT COST AND QUANTITY EFFECTS FOR VEHICLES UNDER ALL REGULATORY STRATEGIES INCLUDING EVAPORATIVE OR ONBOARD AND EVAPORATIVE CONTROL[a]

Control strategy	Model years	Vehicle price increase ($/vehicle)[b]	Reductions in vehicle consumption	
			(10^3/yr)[c]	Percent[d]
Evaporative control				
LMV	1990-94	2.90	3.8	0.03
	1995 on	2.00	2.6	0.02
LDT	1990-94	3.80	1.1	0.03
	1995 on	2.60	0.7	0.02
Onboard and evaporative control				
LMV	1990-94	20.00	26.5	0.24
	1995-99	17.70	23.0	0.21
	2000 on	16.30	21.3	0.19
LDT	1990-94	27.10	7.9	0.22
	1995-99	24.20	6.7	0.19
	2000 on	22.60	6.3	0.18

[a] Quantity effects may be overestimated because cost increases are not reduced by recovery credits attributed to the control strategies. The degree of overestimation depends upon the degree to which vehicle purchasers are aware of efficienty improvements associated with stated vehicle price increases.

[b] LDT estimates are based on weighted averages of single tank and dual tank truck costs.

[c] Reductions are computed using a price elasticity for light vehicles of -1.11.

[d] Percentages are of projected annual LMV or LDT consumption for the relevant period.

While Method I allots overall gasoline consumption reductions attributed to average unit cost increases to model plant categories, Method II estimates consumption reductions by model plant category based on model plant unit cost increases. Because model plant data do not include costs for Stage II in combination with onboard control, Method II cannot be applied to regulatory strategies including this combination. For Stage I control estimates, aggregate Stage I costs for facilities other than service stations are averaged over all gasoline consumption and the resulting unit cost increase is passed forward to all service stations. For each strategy, a percentage reduction in consumption is calculated for each model plant category based on a general price elasticity of demand for gasoline (-0.55) and a percentage price increase for the model plant class. Percentage price increases are based on model plant unit cost increases and an initial gasoline price of 31.7¢/liter. Consumption reductions by model plant class are calculated by applying estimated percentage consumption reductions to total public station throughput in the control area by model plant class for the year 2004. Model plant closures are calculated by dividing consumption reductions for model plant categories by model plant throughputs. The total number of closures is the sum of closures in each model plant class.

The closure analysis includes another calculation that is intended to facilitate evaluation of closure estimates. Under Method I, consumption reductions are allotted to model plant classes without reference to model plant-specific unit cost increases. If it is assumed that retail facilities will attempt to pass on these specific unit cost increases in the form of price increases, each estimated Method I consumption reduction incorporates an implicit demand elasticity for gasoline that is specific to each model plant category. Method I closure estimates may be evaluated by comparing such implicit elasticity estimates to benchmarks for reasonableness. Because gasoline price elasticity estimates vary widely, anything between -0.24 and -1.59 is considered reasonable.

Elasticities implicit in the Method I distribution of closures are estimated in the following manner. For each relevant regulatory strategy and option, a percentage decline in consumption is calculated for each model plant category based on the Method I consumption reduction for the category and total throughput for the category in 2004. Percentage price increases are calculated based on model plant unit cost increases and an initial gasoline price of 31.7¢/liter. Implicit elasticities are calculated by dividing each estimated percentage reduction in quantity by the corresponding estimated percentage increase in price.

E.3.2 Results

Table E-3 provides Method I public service station closure estimates for a variety of regulatory strategies and exemption options that affect service stations. For nationwide Stage I control with exemptions, Method I predicts 60 retail closures, representing 0.04 percent of the initial (1990) public station population. Depending on the exemption option, nationwide Stage II control is expected to close between 150 and 530 stations, representing from 0.09 to 0.32 percent of the base population. Depending on exemption option, under Stage II control for 61 nonattainment areas, Method I predicts from 50 to 250 retail closures, representing 0.03 to 0.15 percent of the base population. Somewhat fewer closures are projected under Stage II in 61 nonattainment areas in combination with onboard control.

Table E-4 presents estimates of the elasticities implicit in the Method I distribution of closures. Based on the benchmarks established, all implicit elasticities estimated for model plants 2, 3 and 4 are reasonable. Many implicit elasticity estimates for model plant 1 are unreasonably low, while those for model plant 5 tend to be high. This indicates that Method I probably generates too few model plant 1 closures and too many (even though few) model plant 5 closures.

Table E-5 provides estimates of public service station closures under Method II. These estimates range from 100 closures (0.06 percent of the 1990 public station population) for nationwide Stage I control with exemptions, to 560 closures (0.33 percent of the base population) for nationwide Stage II control with no exemptions. For Stage II control nationwide, Options A and A^{1} generate the same number of public station closures; only the composition of closures varies between these options, with fewer independents closing under Option A. (Precise estimation of potential differential impacts on independent and nonindependent operators would require a significantly more sophisticated closure methodology.) Options A^{11} and B generate the same number of public station closures under Stage II control because Option A^{11} exempts almost exclusively private stations.

TABLE E-3. PUBLIC SERVICE STATION CLOSURES ATTRIBUTED TO SELECTED REGULATORY STRATEGIES UNDER METHOD I[a]

Regulatory strategy	Option[b]	Reduction in gasoline consumption (10^6 ℓ/yr)	Closures: Number	Closures: Percent of 1990 public station population
Stage I--nationwide	A,A^1	120	60	0.04
Stage II--nationwide[c]	A	290-320	150-160	0.09-0.10
	A^1	350-410	180-210	0.11-0.13
	A^{11}	560-640	360-420	0.21-0.25
	B	710-820	460-530	0.27-0.32
Stage II--61 nonattainment areas[c]	A	100-150	50-80	0.03-0.05
	A^1	130-200	60-100	0.04-0.06
	A^{11}	200-310	130-200	0.08-0.12
	B	250-390	160-250	0.10-0.15
Stage II, and onboard--61 nonattainment areas[c]	A	80-130	40-60	0.03-0.04
	A^1	110-160	50-80	0.03-0.05
	A^{11}	150-250	100-160	0.06-0.09
	B	180-290	120-190	0.07-0.11

[a] Closure estimates are based on estimated reductions in gasoline consumption attributed to average unit cost increases associated with the regulatory strategies. Under Method I, consumption reductions are allotted to model plant classes in accordance with the public throughput distribution in 2004, midway through the period of analysis. This year was chosen because closures are expected to occur earlier rather than later in the period of analysis.

[b] Options A,A^1, and A^{11} include throughput-based size exemptions for bulk plants and service stations. Under Stage I control, Options A and A^1 exempt bulk plants with throughputs <10,000 gal/mo from outgoing balance controls and service stations with throughputs <10,000 gal/mo from all controls. Under Stage II control, Option A exempts independent and nonindependent service stations with <50,000 gal/mo and <10,000 gal/mo throughputs, respectively. Options A^1 and ^{11} exempt all stations with throughputs <10,000 gal/mo and <2,000 gal/mo, respectively. Option B includes no exemptions.

[c] Ranges are based on cost ranges provided in Chapter 3, Tables 3-6, 3-12, and 3-13 (less enforcement expenditures).

TABLE E-4. ELASTICITIES IMPLICIT IN METHOD I CLOSURE ESTIMATES[a,b]

Regulatory strategy	Model plants 1	2	3	4	5
Stage I--nationwide[c]	-	-0.31	-0.44	-0.58	-0.76
Stage II--nationwide[d]	-0.16 to -0.24[d]	-0.27 to -0.74	-0.27 to -0.72	-0.39 to -1.05	-1.13 to -3.10[d]
Stage II--61 nonattainment areas[d]	-0.17 to -0.33[d]	-0.27 to -1.00	-0.27 to -0.98	-0.39 to -1.42	-1.14 to -4.18

[a] Method I allots consumption reductions attributable to overall average unit cost increases to model plant classes in accordance with the public station throughput distribution for 2004. The resulting percentage declines in throughput for each model plant class, estimated unit cost increases by model plant class, and an overall initial gasoline price are used to estimate the elasticities implicit in the Method I distribution of closures. No estimates are provided for strategies including Stage II in combination with onboard control because model plant unit cost estimates are not available for these strategies.

[b] Gasoline price elasticity estimates vary widely. Anything between -0.24 and -1.59 is considered reasonable. (-0.55 is used in other parts of this analysis.)

[c] Estimates are for Options A and A^1 only. (Model plant 1 exempted).

[d] Ranges provided are based on cost ranges for various exemption and nonexemption options.

TABLE E-5. PUBLIC SERVICE STATION CLOSURES ATTRIBUTED TO NATIONWIDE REGULATORY STRATEGIES UNDER METHOD II[a]

Regulatory strategy	Option[b]	Closures	
		Number	Percent of 1988 public station population
Stage I--nationwide	A^{1}	100	0.06
Stage II--nationwide	A	270	0.16
	A^{1}	270	0.16
	A^{11}	560	0.33
	B	560	0.33
Stage II--61 nonattainment areas	A	90	0.06
	A^{1}	90	0.06
	A^{11}	200	0.12
	B	200	0.12

[a] Closure estimates are based on estimated reductions in gasoline consumption attributed to model plant unit cost increases associated with the regulatory strategies. Stage II model plant costs are based on a weighted average of Stage II system costs provided in Appendix B, Table B-17. Because model plant cost estimates are not available for Stage II in combination with onboard control, no Method II closure estimates are provided for strategies involving this combination. Under Method II, closures are estimated in the following manner: (1) Unit cost increases by service station model plant class are estimated based on model plant costs. Stage I costs for other types of facilities are averaged across all gasoline consumption and passed on to all service stations; (2) Consumption declines by model plant category are estimated by applying a general price elasticity for gasoline (-0.55) to percentage price increases for model plant classes. The same initial price is assumed to apply in all model plant classes. Initial quantities by model plant class are based on public station throughputs for the year 2004; (3) Closures are calculated by dividing consumption declines for the model plant classes by plant sizes.

[b] Options A, A^{1}, and A^{11} include throughput-based size exemptions for bulk plants and service stations. Under Stage I control, Options A and A^{1} exempt bulk plants with throughputs <10,000 gal/mo from outgoing balance controls and service stations with throughputs <10,000 gal/mo from all controls. Under Stage II control, Option A exempts independent and non-independent service stations with <50,000 gal/mo and <10,000 gal/mo throughputs, respectively. Options A^{1} and A^{11} exempt all stations with throughputs <10,000 gal/mo and <2,000 gal/mo, respectively. Option B includes no exemptions.

When compared with Method I, Method II allocates a larger fraction of the overall decline in gasoline consumption to model plant categories 1, 2 and 3 and a smaller fraction to model plant categories 4 and 5. Accordingly, Method II generally produces more estimated closures than Method I. Under nationwide Stage I control with exemptions, Method II predicts 56 percent more closures than Method I. For nationwide Stage II control, Method II generates 7 to 84 percent more closures than Method I. Furthermore, Method II closes more of the smallest facilities and fewer of the largest facilities than Method I. Based on the evidence provided by implicit elasticity calculations, Method II is preferable to Method I in this respect.

E.4 FINANCIAL ANALYSIS

This section addresses the concern that smaller gasoline marketing firms, especially those that own service stations, will have more difficulty financing control expenditures than larger firms. The financial ratio analysis conducted does not support this contention. In fact, the analysis indicates that there is no simple, direct relationship between firm size and financial health. There are both profit and loss earning firms in all size categories and, as the estimated financial ratios indicate, credit worthiness depends more on the profit position of the firm than on its size.

Controls must be financed by a combination of internally and externally generated funds. The existence of internal funds and availability of external funds depend on the firm's financial health. Financial ratio analysis is the selected method for evaluating financial health. Accordingly, this section provides a financial ratio analysis for firms in SIC 5541, Gasoline Service Stations. Ratios are examined by firm employment size (Table E-6) and by firm asset size (Tables E-7 and E-8). Ratios by asset size are shown for firms earning profits in the year specified (Table E-7) and for firms earning losses during the same year (Table E-8). Liquidity, leverage, and profitability ratios are considered in the following manner.

E.4.1 Financial Ratios Examined

The quick ratio, a liquidity ratio, measures a firm's ability to meet its short-term obligations. The quick ratio is considered a measure of solvency. The higher the quick ratio, the more liquid the firm's position and the more "breathing room" it has.

TABLE E-6. SIC 5541 FINANCIAL RATIOS BY FIRM EMPLOYMENT SIZE[a]

Financial ratios[b]	Total firm employment 1-19	20-99	100-499	>500
Quick ratio	1.17	0.88	0.82	0.73
Debt/net worth	0.72	1.14	1.33	1.80
Profit margin	0.025	0.017	0.015	0.012
Profit on net worth	0.152	0.138	0.161	0.089
Long-term debt/assets	0.140	0.156	0.150	0.136

[a] All values are in ratio form; none have been converted to percentages. All calculations are based on FINSTAT data for 1976 through 1981, provided to EPA by the Small Business Administration (SBA). For consistency, all ratios are calculated from mean raw data and are thus ratios of means rather than mean ratios. (Data provided by SBA includes mean values for some, but not all, of the above ratios.)

[b] Ratios are defined as follows:

Quick ratio = (current assets-inventories)/current debt
Debt/net worth = total debt/tangible net worth
Profit margin = net profit/net sales
Profit on net worth = net profit/tangible net worth
Long-term debt/assets = total long-term debt/total assets

TABLE E-7. SIC 5541 FINANCIAL RATIOS BY FIRM ASSET SIZE FOR FIRMS EARNING PROFITS[a]

Financial ratios[b]	All firms	Firm asset size (10^6 \$) Zero assets	0.001-0.099	0.100-0.249	0.250-0.499	0.500-0.999	1.000-4.999	5.000-9.999	10.0-24.99	10.00-24.99
Quick ratio	0.70	N/A	1.21	0.93	0.89	1.02	0.84	0.76	0.57	0.52
Debt/net worth	1.48	N/A	1.05	1.57	1.78	1.12	1.20	1.78	1.57	5.76
Coverage	5.72	20.11	17.67	7.71	4.57	4.25	4.75	3.79	5.12	2.50
Profit margin	0.013	0.277	0.018	0.016	0.012	0.011	0.011	0.008	0.009	0.007
Profit on net worth	0.219	N/A	0.581	0.423	0.233	0.136	0.135	0.147	0.154	0.192
Long-term debt/assets	0.191	N/A	0.220	0.221	0.327	0.209	0.157	0.247	0.166	0.130
Beaver's ratio	0.311	N/A	0.757	0.438	0.276	0.310	0.282	0.262	0.276	0.119

[a] Schonfeld & Associates, Inc. IRS Corporate Financial Ratios. Second Edition. 1984. pp. 393-394. Ratios are based on IRS data from returns with accounting periods ending from July 1980 to June 1981.

[b] Ratios are defined as follows:

Quick ratio = (current assets-inventories)/current debt
Debt/net worth = total debt/tangible net worth
Coverage = (profit before taxes + interest charges)/interest charges
Profit margin = net profit/net sales
Profit on net worth = net profit/tangible net worth
Long-term debt/assets = total long-term debt/total assets
Beaver's ratio = (earnings before interest and taxes + depreciation)/total debt

TABLE E-8. SIC 5541 FINANCIAL RATIOS BY FIRM ASSET SIZE FOR FIRMS EARNING LOSSES[a]

Financial ratios[b]	All firms	Firm asset size (10⁶ $) Zero assets	0.001-0.099	0.100-0.244	0.250-0.499	0.500-0.999	1.000-4.999	5.000-9.999	10.00-24.99	100.0-24.99
Quick ratio	0.46	N/A	0.49	0.42	0.40	0.46	0.36	N/A	0.36	0.49
Debt/net worth	9.15	N/A	-67.91	-9.67	424.82	14.38	8.11	N/A	8.94	8.32
Coverage	-0.98	0.74	-4.91	-1.17	-2.56	-0.40	-0.32	N/A	-0.59	-0.76
Profit margin	-0.015	-0.001	-0.023	-0.021	-0.030	-0.026	-0.018	N/A	-0.007	-0.006
Profit on net worth	-0.914	N/A	N/A	N/A	-78.854	-1.219	-0.750	N/A	-0.699	-0.444
Long-term debt/assets	0.390	N/A	0.621	0.750	0.652	0.581	0.384	N/A	0.236	0.112
Beaver's ratio	0.005	N/A	N/A	N/A	-0.075	0.035	0.046	N/A	0.039	0.010

[a] Schonfeld & Associates, Inc. IRS Corporate Financial Ratios. Second Edition. 1984. pp. 393-394. Ratios are based on IRS data from returns with accounting periods ending from July 1980 to June 1981.

[b] Ratios are defined as follows:

Quick ratio = (current assets-inventories)/current debt
Debt/net worth = total debt/tangible net worth
Coverage = (profit before taxes + interest charges)/interest charges
Profit margin = net profit/net sales
Profit on net worth = net profit/tangible net worth
Long-term debt/assets = total long-term debt/total assets
Beaver's ratio = (earnings before interest and taxes + depreciation)/total debt

Leverage ratios used include the ratio of debt to net worth and the coverage ratio. The debt/net worth ratio indicates the extent to which the firm's assets are financed with contractual obligations (debt). It exhibits the relationship between capital contributed by creditors versus owners. The higher this ratio the lower the firm's future debt capacity. A high ratio results in a high cost of capital to the firm and indicates vulnerability to downward business cycles. The coverage ratio measures a firm's ability to meet its obligations arising from the use of borrowed funds and affects a firm's ability to obtain loans.

The profitability ratios considered are the profit margin and the ratio of profit to net worth. The profit margin measures the fraction of dollar sales converted to net income. The higher this ratio, the more attractive the firm to all providers of funds (debt or equity). If the profit margin is too low, either product price is too low or costs are too high. The ratio of profit to net worth is increasingly regarded as the final criterion of profitability. If this ratio is too low, the firm cannot attract risk capital (equity) and will probably also have difficulty obtaining loans. Continued viability requires a ratio in excess of the risk-free interest rate outside the industry. A ratio in excess of 0.1 is desirable in order to provide dividend payments and funds for growth.

Two additional ratios are considered: long-term debt to total assets and Beaver's ratio. The ratio of long-term debt to total assets is needed to supplement the coverage ratio because a firm may exhibit a low coverage ratio as a result of efficient management and still have substantial long term debt capacity. (Control capital is frequently financed through long-term as opposed to short-term debt.) Beaver's ratio is included because it is considered a good predictor of business failure.

E.4.2 Ratio Estimates

When examined by employment size class, the quick ratio ranges from 0.73 to 1.17. Ratio estimates decrease with firm size indicating that smaller firms are more liquid than larger firms. When single-year data are examined by asset size, the quick ratio ranges from 0.52 to 1.21 for profitable firms and from 0.36 to 0.49 for firms earning losses. For profitable firms, the quick ratio decreases with size and only the two largest classes produce ratios below the figure of 0.46 for all firms. There is little dispersion in ratios for firms earning losses. Clearly, a firm's profit or loss status affects solvency much more than size.

The long-term debt to total assets ratio is used to supplement the quick ratio, which does not consider long-term debt capacity. When examined by employment size class, this ratio ranges from 0.136 to 0.156. The largest firms generate the smallest ratios, indicating less existing debt compared to assets and, therefore, a greater capacity for increased debt. However, the largest ratios are not associated with the smallest firms, but rather with midsize firms. When examined by firm asset size, this ratio ranges from 0.130 to 0.327 for profitable firms and from 0.112 to 0.75 for firms earning losses. For all firms the figures are 0.191 for profit-makers and 0.39 for loss-earners. Whether among profitable or losing firms, the largest firms produce the smallest ratios but the smallest firms do not produce the largest ratios. The all-firm value for companies earning losses is higher than all values associated with profitable firms.

The debt/net worth ratio ranges from 0.72 to 1.80 across employment size classes. This ratio increases with firm size and is greater than 1.0 for all except the smallest firms. Therefore, the smallest firms should have the greatest capacity for future debt. When examined by firm asset size, the debt/net worth ratio ranges from 1.05 to 5.76 for profitable firms and from -67.91 to 424.82 for firms earning losses. (Negative values indicate negative net worth.) The all-firm values are 1.48 for profit-makers and 9.15 for loss earners. While the ratios for firms earning profits exhibit no clear pattern across asset size categories, the ratios for firms earning losses do have regularity. Smaller firms exhibit either negative or large, positive ratios. The lowest positive value among firms earning losses is higher than the highest positive value for firms earning profits. Furthermore, there is much greater dispersion in the ratios for losing companies. As with the quick ratio, basic profitability appears to be a more important determinant of leverage than firm size.

The coverage ratio, available by firm asset size only, ranges from 2.50 to 20.11 for profitable companies and from -2.56 to 0.74 for firms earning losses. The all-firm average is 5.72 for profit-makers and -0.98 for loss-earners. (Negative values occur when profit before taxes plus interest charges is negative.) For profitable firms, the largest ratios (the greatest coverage) are associated with the smallest firms. For companies earning losses, smaller firms (except the smallest) have small ratios (less coverage). Thus, the relationship between size and coverage varies with profit status.

When examined by employment size, the profit margin decreases with firm size from 0.025 to 0.012. When examined by firm asset size, the ratios for profitable companies also decrease with size, from 0.277 to 0.007. For firms earning negative profits, the profit margin is negative and ranges from -0.001 to -0.030. The ratios for the smallest firms are the least negative, while midsize firms produce the most negative and, therefore, the worst ratios. As expected in this case, profit status is more important than firm size. Moreover, among profitable firms, the profit margin is highest for the smaller firms.

The profit on net worth ratio by employment size class ranges from 0.089 to 0.161. The larger firms produce the lowest and highest ratios. Only the largest class exhibits a ratio under 0.10 (greater than 0.10 is desirable). All other classes produce acceptable values. When examined by asset size, the ratio ranges from 0.135 to 0.581 for profitable firms and from -0.444 to -78.854 for firms earning losses. For profitable companies, the all-firm estimate is 0.219 and only the smaller companies exhibit higher (more desirable) ratios. Among firms earning losses, the ratio improves as the firm size increases. (A small negative value is more desirable than a large negative value.) Thus, the relationship between profit on net worth and firm size depends on the profit status of the firms.

Beaver's ratio is available only by firm asset size. For profitable companies, it ranges from 0.119 to 0.757, with an all-firm value of 0.311. The ratio tends to decrease with firm size, with only the smaller firms showing ratios in excess of the all-firm figure. Among firms earning losses, this ratio is much lower, ranging from -0.075 to -0.046. Only one class generates a negative value. Among the positive values, the largest class yields the smallest ratio. Beaver's ratio is sometimes considered to indicate problems if the ratio is less than 0.08. An alternative critical value is 0.12. All profitable firm classes pass this test; loss-earning firm classes do not.

In summary, the financial ratio analysis indicates that there is no simple, direct relationship between firm size and financial health. For some ratios, smaller firms produce the "best" values, while larger firms produce the "worst" values. For most ratios, the profit position of the firm is more important than firm size in determining the desirability of the ratio value. Moreover, for several ratios the relationship between firm size and ratio value is reversed for profit and loss earning firms. (Among profitable firms, smaller entities produce more desirable values than larger firms, while among losing firms, smaller entities produce the least desirable values.) Thus, this analysis does not substantiate the contention that smaller gasoline marketing firms will have more difficulty than larger firms in financing control expenditures.

APPENDIX F

BASELINE EMISSIONS TABLES

APPENDIX F

BASELINE EMISSIONS TABLES

Appendix F contains four tables detailing the Agency's State-by-State estimates of baseline emissions from the four principal emission sources in the gasoline marketing network. Table F-1 provides estimates for bulk gasoline terminals (tank truck loading), Table F-2 for bulk terminal storage tanks, Table F-3 for bulk plants, and Table F-4 for service station operations. These emission estimates reflect quantities of gasoline vapors (total hydrocarbons) emitted from these operations. To determine total benzene emissions in each table, the total vapor estimates were multiplied either by 0.0060 (for all Stage I operations including service station storage tanks) or by 0.0066 (for vehicle refueling).

The basic methodology used to calculate baseline emissions was very similar to the one used in Appendix B of the July 1984 Strategies Document. Emission factors were selected to represent the degree of control (or lack of control) on emissions within various areas of each State, and emissions were calculated by multiplying the emission factors by the corresponding throughput for each area. To simplify the presentation in this appendix, the values in these tables are based on the assumption of nationwide average fuel temperatures and RVP's. In the calculation of impacts in nonattainment areas, gasoline RVP's and temperatures are varied according to the data contained in Table 2-1 of Chapter 2.

Changes from the previous emissions calculations, with the exception of the new emission factors discussed in Chapter 3, were minor. Based on comments, the presumed regulatory coverage (and hence, emission factors) for a few areas was updated to more accurately reflect the present situation in those areas. Also, assumptions concerning the numbers and types of storage tank seals in use were adjusted slightly.

Table F-1. BULK TERMINAL BASELINE EMISSIONS

STATE	1982 NATIOWIDE BASELINE UNCONTROLLED THROUGHPUT (1000's liters)	1982 NATIOWIDE BASELINE CONTROLLED THROUGHPUT (1000's liters)	1982 "27 AREAS" NONATTAINMENT UNCONTROLLED THROUGHPUT (1000's liters)	1982 "27 AREAS" NONATTAINMENT CONTROLLED THROUGHPUT (1000's liters)	"11 AREAS" NONATTAINMENT UNCONTROLLED THROUGHPUT (1000's liters)	"11 AREAS" NONATTAINMENT CONTROLLED THROUGHPUT (1000's liters)
Alabama	0	7,217,995	0	1,031,299	0	0
Alaska	519,677	0	0	0	0	0
Arizona	4,931,900	0	2,575,333	0	2,575,333	0
Arkansas	3,770,707	545,884	0	0	0	0
California	0	38,525,020	0	0	0	0
San Diego	0	2,984,120	0	0	0	0
Colorado	2,715,332	2,771,248	0	2,771,248	0	0
Connecticut	0	4,911,193	0	0	0	0
Delaware	423,897	657,720	0	657,719	0	0
District of Columbia	0	1,020,116	0	0	0	0
Florida	8,191,527	9,450,263	0	0	0	0
Georgia	0	10,678,632	0	3,597,537	0	3,597,537
Hawaii	1,188,202	0	0	0	0	0
Idaho	1,698,519	0	0	0	0	0
Illinois	0	17,246,996	0	10,181,764	0	10,181,764
Indiana	7,390,000	2,339,667	0	1,195,772	0	919,641
Iowa	5,328,341	0	0	0	0	0
Kansas	3,734,618	805,274	0	0	0	0
Kentucky	615,555	5,800,297	0	1,005,622	0	0
Louisiana	0	7,721,294	0	610,594	0	0
Maine	547,954	1,372,066	0	0	0	0
Maryland	1,649,200	5,923,554	0	5,923,554	0	4,660,022
Massachusetts	0	8,428,661	0	5,965,641	0	0
Michigan	0	15,759,255	0	6,041,999	0	0
Minnesota	7,415,178	0	0	0	0	0
Mississippi	4,365,948	0	0	0	0	0
Missouri	4,778,419	0	0	0	0	0
Clay	0	1,347,604	0	0	0	0
Franklin	0	3,196,943	0	3,196,943	0	3,196,943
Montana	1,598,519	0	0	0	0	0
Nebraska	2,878,560	0	0	0	0	0
Nevada	265,654	0	0	0	0	0
Clark	0	936,504	0	0	0	0
Douglas	0	593,110	0	0	0	0
New Hampshire	0	1,530,400	0	0	0	0
New Jersey	0	11,858,791	0	11,858,791	0	11,858,791
New Mexico	2,264,452	632,413	0	0	0	0
New York	4,085,878	16,368,660	0	9,543,401	0	9,543,401
North Carolina	10,096,147	569,124	0	0	0	0
North Dakota	1,241,544	0	0	0	0	0
Ohio	8,267,378	9,837.137	0	0	0	0
Oklahoma	4,672,230	1,710,663	0	773,098	0	0
Oregon	2,024,229	2,843,932	0	0	0	0
Pennsylvania	0	17,725,227	0	8,883,210	0	4,475,627
Rhode Island	0	1,356,552	0	0	0	0
South Carolina	0	5,766,603	0	0	0	0
South Dakota	1,396,124	0	0	0	0	0
Tennessee	0	8,913,653	0	0	0	0
Texas	18,094,302	11,105,171	266,551	8,222,651	0	8,222,651
Utah	1,504,374	1,010,232	0	1,010,122	0	0
Vermont	0	890,182	0	0	0	0
Virginia	7,210,118	2,417,832	0	1,870,509	0	1,870,509
Washington	3,525,005	3,380,070	0	0	0	0
West Virginia	2,570,935	615,328	0	0	0	0
Wisconsin	0	7,886,381	0	2,274,800	0	0
Wyoming	1,317,589	0	0	0	0	0

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Table F-1. BULK TERMINAL BASELINE EMISSIONS (continued)

STATE	1984 UNCONTROLLED THROUGHPUT (1000's liters)	1984 CONTROLLED THROUGHPUT (1000's liters)	CTG CONTROL LEVEL (mg/l)	((UNCONTRLD LODNG RCK SUBMGD LOSS (Mg/yr)	UNCONTRLD LODNG RCK SPLASH LOSS (Mg/yr)	CONTRLD LODNG RCK LOSS (@35 mg/l) (Mg/yr)	WITH BASELINE CONTROLS CONTRLD LODNG RCK LOSS (@90%, 80 mg/l) (Mg/yr)	CONTRLD TANK TRUCK CONTROL LEVEL (mg/l)
Alabama	0	7,016,385	80.0	0	0	147	225	400.5
Alaska	505,154	0		380	59	0	0	
Arizona	4,794,076	0		3,610	557	0	0	
Arkansas	3,665,333	530,629	80.0	2,760	426	11	17	133.5
California	0	37,448,420	80.0	0	0	786	1,198	133.5
San Diego	0	2,900,727	133.5	0	0	61	155	133.5
Colorado	2,639,451	2,693,804	80.0	1,987	307	57	86	133.5
Connecticut	0	4,773,947	80.0	0	0	100	153	133.5
Delaware	412,051	639,340	80.0	310	48	13	20	133.5
District of Columbia	0	999,385	133.5	0	0	21	53	400.5
Florida	7,962,611	9,186,171	80.0	5,996	925	193	294	133.5
Georgia	0	10,380,213	80.0	0	0	218	332	400.5
Hawaii	1,154,997	0		870	134	0	0	
Idaho	1,651,053	0		1,243	192	0	0	
Illinois	0	16,765,021	80.0	0	0	352	536	400.5
Indiana	7,183,561	2,274,284	80.0	5,409	834	48	73	133.5
Iowa	5,179,438	0		3,900	602	0	0	
Kansas	3,630,252	860,535	80.0	2,733	422	18	28	133.5
Kentucky	598,353	5,715,969	80.0	451	69	120	183	133.5
Louisiana	0	7,505,519	80.0	0	0	158	240	133.5
Maine	532,641	1,333,723	80.0	401	62	28	43	400.5
Maryland	1,603,120	5,758,018	80.0	1,207	186	121	184	133.5
Massachusetts	0	8,193,118	133.5	0	0	172	438	133.5
Michigan	0	15,318,855	80.0	0	0	322	490	133.5
Minnesota	7,207,957	0		5,427	837	0	0	
Mississippi	4,243,940	0		3,196	493	0	0	
Missouri	4,644,884	0		3,497	539	0	0	
Clay	0	1,309,945	80.0	0	0	28	42	133.5
Franklin	0	3,107,603	132.0	0	0	65	164	133.5
Montana	1,553,848	0		1,170	180	0	0	
Nebraska	2,798,117	0		2,107	325	0	0	
Nevada	258,230	0		194	30	0	0	
Clark	0	910,333	133.5	0	0	19	49	133.5
Douglas	0	576,535	80.0	0	0	12	18	133.5
New Hampshire	0	1,487,632	80.0	0	0	31	48	133.5
New Jersey	0	11,527,391	80.0	0	0	242	369	133.5
New Mexico	2,201,171	614,740	133.5	1,657	256	13	33	133.5
New York	3,971,696	15,911,230	80.0	2,991	461	334	509	400.5
North Carolina	9,814,005	553,220	80.0	7,390	1,140	12	18	133.5
North Dakota	1,286,848	0		909	140	0	0	
Ohio	8,036,342	9,562,234	80.0	6,051	933	201	306	133.5
Oklahoma	4,541,662	1,670,634	80.0	3,420	528	35	53	133.5
Oregon	1,967,661	2,764,457	80.0	1,482	229	58	88	133.5
Pennsylvania	0	17,229,887	80.0	0	0	362	551	133.5
Rhode Island	0	1,318,643	80.0	0	0	28	42	400.5
South Carolina	0	5,605,453	80.0	0	0	118	179	400.5
South Dakota	1,357,109	0		1,022	158	0	0	
Tennessee	0	8,664,557	80.0	0	0	182	277	133.5
Texas	17,500,648	10,794,832	80.0	13,244	2,043	227	345	301.2
Utah	1,462,334	982,001	80.0	1,101	170	21	31	133.5
Vermont	0	865,385	80.0	0	0	18	28	400.5
Virginia	7,000,628	2,350,265	80.0	5,277	814	49	75	400.5
Washington	3,426,497	3,293,389	80.0	2,580	398	69	105	133.5
West Virginia	2,499,089	598,132	80.0	1,882	290	13	19	400.5
Wisconsin	0	7,665,952	80.0	0	0	161	245	133.5
Wyoming	1,280,768	0		964	149	0	0	
NATIONWIDE				96,816	14,934	5,243	8,345	

Table F-1. BULK TERMINAL BASELINE EMISSIONS (concluded)

STATE	CONTRLD TANK TRUCK LOSS (Mg/yr)	TOTAL STATE LOSSES (Mg/yr)	TOTAL BENZENE LOSSES (Mg/yr)
Alabama	2,810	3,182	
Alaska	0	439	
Arizona	0	4,167	
Arkansas	71	3,285	
California	4,999	6,984	
San Diego	387	603	
Colorado	360	2,796	
Connecticut	637	890	
Delaware	85	477	
District of Columbia	400	475	
Florida	1,226	1,634	
Georgia	4,157	4,708	
Hawaii	0	1,004	
Idaho	0	1,435	
Illinois	6,715	7,603	
Indiana	304	6,667	
Iowa	0	4,501	
Kansas	115	3,316	
Kentucky	763	1,586	
Louisiana	1,002	1,400	
Maine	534	1,068	
Maryland	769	2,467	
Massachusetts	1,094	1,703	
Michigan	2,045	2,857	
Minnesota	0	6,264	
Mississippi	0	3,688	
Missouri	0	4,837	
Clay	175	244	
Franklin	415	644	
Montana	0	1,350	
Nebraska	0	2,432	
Nevada	0	224	
Clark	122	189	
Douglas	77	108	
New Hampshire	193	277	
New Jersey	1,539	2,150	
New Mexico	82	2,041	
New York	6,373	10,668	
North Carolina	74	8,633	
North Dakota	0	1,049	
Ohio	1,277	8,768	
Oklahoma	223	4,259	
Oregon	369	2,226	
Pennsylvania	2,300	3,213	
Rhode Island	528	598	
South Carolina	2,245	2,542	
South Dakota	0	1,179	
Tennessee	1,157	1,616	
Texas	3,252	19,110	
Utah	131	1,454	
Vermont	347	392	
Virginia	941	7,157	
Washington	440	3,592	
West Virginia	240	2,443	
Wisconsin	1,023	1,430	
Wyoming	0	1,113	
NATIONWIDE	52,001	177,339	1,064

Table F-2. BULK TERMINAL STORAGE TANK BASELINE EMISSIONS

STATE	1982 NATIONWIDE UNCONTROLLED THROUGHPUT (1000's liters)	1982 NATIONWIDE CONTROLLED THROUGHPUT (1000's liters)	1982 "27 AREAS" NONATTAINMENT UNCONTROLLED THROUGHPUT (1000's liters)	1982 "27 AREAS" NONATTAINMENT CONTROLLED THROUGHPUT (1000's liters)	1982 "11 AREAS" NONATTAINMENT UNCONTROLLED THROUGHPUT (1000's liters)	1982 "11 AREAS" NONATTAINMENT CONTROLLED THROUGHPUT (1000's liters)
Alabama	0	7,217,995	0	1,031,400	0	0
Alaska	519,677	0	0	0	0	0
Arizona	4,931,900	0	0	2,575,605	0	2,575,605
Arkansas		545,884	0	0	0	0
California			0	0	0	0
Colorado	2,715,332	2,771,248	0	2,771,541	0	0
Connecticut	0	4,911,193	0	0	0	0
Delaware	423,897	657,720	0	657,789	0	657,789
District of Columbia	0	1,020,116	0	0	0	0
Florida	8,191,527	9,450,263	0	0	0	0
Georgia	0	10,678,632	0	3,597,917	0	3,597,917
Hawaii	1,180,202	0	0	0	0	0
Idaho	1,690,519	0	0	0	0	0
Illinois	0	17,246,996	0	10,182,840	0	10,182,840
Indiana	7,390,000	2,339,667	0	1,195,899	0	919,739
Iowa	5,320,341	0	0	0	0	0
Kansas		805,274	0	0	0	0
Kentucky			0	1,005,728	0	0
Louisiana	0	7,721,294	0	610,659	0	0
Maine	547,954	1,372,066	0	0	0	0
Maryland	1,649,200	5,923,554	0	5,924,100	0	2,021,762
Massachusetts	0	8,420,661	0	5,966,271	0	0
Michigan	0	15,759,255	0	6,042,638	0	0
Minnesota	7,415,170	0	0	0	0	0
Mississippi	4,365,940	0	0	0	0	0
Missouri	4,770,419	4,544,547	0	3,197,281	0	3,197,281
Montana	1,550,519	0	0	0	0	0
Nebraska			0	0	0	0
Nevada	265,654	1,529,614	0	0	0	0
New Hampshire	0	1,530,400	0	0	0	0
New Jersey	0	11,850,791	0	11,860,044	0	11,860,044
New Mexico	2,264,452	632,413	0	0	0	0
New York	4,005,870	16,360,660	0	9,544,409	0	9,544,409
North Carolina	10,096,147	569,124	0	0	0	0
North Dakota	1,241,544	0	0	0	0	0
Ohio	1,005,332	16,299,183	0	0	0	0
Oklahoma	4,672,230	1,710,663	0	773,179	0	0
Oregon	2,024,229	2,843,932	0	0	0	0
Pennsylvania	0	17,725,227	0	8,210,620	0	4,480,100
Rhode Island	0	1,356,552	0	0	0	0
South Carolina	0	5,766,603	0	0	0	0
South Dakota	1,396,124	0	0	0	0	0
Tennessee	0	8,913,653	0	0	0	0
Texas	16,454,602	12,744,871	266,579	8,223,520	266,579	8,223,520
Utah	990,100	1,516,506	0	1,010,229	0	0
Vermont	565,232	324,950	0	0	0	0
Virginia	7,210,118	2,417,032	0	1,870,707	0	1,870,707
Washington	3,525,005	3,380,070	0	0	0	0
West Virginia	2,570,935	615,320	0	0	0	0
Wisconsin			0	2,275,041	0	0
Wyoming	1,317,509	0	0	0	0	0
NATIONWIDE TOTAL	113,235,872	209,602,737	266,579	88,535,504	266,579	59,131,714

Table F-2. BULK TERMINAL STORAGE TANK BASELINE EMISSIONS (continued)

STATE	1984 UNCONTROLLED THROUGHPUT IN SELECTED AREAS (1000's barrels)	1984 CONTROLLED THROUGHPUT IN SELECTED AREAS (1000's barrels)	AREAS UNCTRLD AT BASELINE NO. OF TANKS	AREAS UNCTRLD AT BASELINE NO. OF TANKS FIXED	AREAS UNCTRLD AT BASELINE NO. OF TANKS FLOATING PRIMARY SEAL	AREAS UNCTRLD AT BASELINE NO. OF TANKS FLOATING SECONDARY SEAL	AREAS CNTRLD AT BASELINE NO. OF TANKS
Alabama	0	44,118	0	0	0	0	94
Alaska	3,176	0	8	2	5	1	0
Arizona	14,405	15,743	36	10	23	4	34
Arkansas	24,200	3,337	60	16	38	6	7
California	65,600	188,053	164	44	103	16	402
Colorado	16,597	16,938	41	11	26	4	36
Connecticut	0	30,018	0	0	0	0	64
Delaware	2,591	4,020	6	2	4	1	9
District of Columbia	0	6,284	0	0	0	0	13
Florida	50,068	57,762	125	34	79	13	123
Georgia	0	65,270	0	0	0	0	139
Hawaii	7,263	0	18	5	11	2	0
Idaho	10,382	0	26	7	16	3	0
Illinois	0	105,417	0	0	0	0	225
Indiana	45,170	14,301	113	30	71	11	31
Iowa	32,568	0	81	22	51	8	0
Kansas	22,902	5,411	57	15	36	6	12
Kentucky	3,763	35,945	9	3	6	1	77
Louisiana	0	47,194	0	0	0	0	101
Maine	3,349	8,386	8	2	5	1	18
Maryland	10,000	36,206	25	7	16	3	77
Massachusetts	0	51,518	0	0	0	0	110
Michigan	0	96,324	0	0	0	0	206
Minnesota	45,323	0	113	31	71	11	0
Mississippi	26,686	0	67	18	42	7	0
Missouri	29,207	27,777	73	20	46	7	59
Montana	9,771	0	24	7	15	2	0
Nebraska	17,597	0	44	12	28	4	0
Nevada	0	10,973	0	0	0	0	23
New Hampshire	0	9,354	0	0	0	0	20
New Jersey	0	72,404	0	0	0	0	155
New Mexico	13,841	3,863	35	9	22	3	8
New York	24,974	100,049	62	17	39	6	214
North Carolina	61,710	3,479	154	42	97	15	7
North Dakota	7,589	0	19	5	12	2	0
Ohio	11,035	99,624	28	7	17	3	213
Oklahoma	28,558	10,585	71	19	45	7	22
Oregon	12,373	17,383	31	8	19	3	37
Pennsylvania	0	108,340	0	0	0	0	231
Rhode Island	0	8,292	0	0	0	0	18
South Carolina	0	35,247	0	0	0	0	75
South Dakota	8,533	0	21	6	13	2	0
Tennessee	0	54,482	0	0	0	0	116
Texas	100,574	77,899	251	68	158	25	166
Utah	6,101	9,269	15	4	10	2	20
Vermont	5,441	0	14	4	9	1	0
Virginia	44,070	14,770	110	30	69	11	32
Washington	21,546	20,709	54	15	34	5	44
West Virginia	15,714	3,761	39	11	25	4	8
Wisconsin	22,135	26,073	55	15	35	6	56
Wyoming	8,053	0	20	5	13	2	0
NATIONWIDE TOTAL	833,030	1,546,590	2,080	562	1,311	208	3,305

Table F-2. BULK TERMINAL STORAGE TANK BASELINE EMISSIONS (continued)

STATE	AREAS CNTRLD AT BASELINE % OF FLOATING W/ PRIMARY SEAL	AREAS CNTRLD AT BASELINE % OF FLOATING W/ SECONDARY SEAL	AREAS CNTRLD AT BASELINE NO. OF TANKS FLOATING PRIMARY SEAL	AREAS CNTRLD AT BASELINE NO. OF TANKS FLOATING SECONDARY SEAL	AREAS UNCTRLD AT BASELINE STRG LOSS PRIM SEAL (Mg/yr)	AREAS UNCTRLD AT BASELINE STRG LOSS SEC SEAL (Mg/yr)	AREAS UNCTRLD AT BASELINE STRG LOSS FIXED ROOF (Mg/yr)
Alabama	0.0	1.0	0	94	0.00	0.00	0.00
Alaska	0.0	0.0	0	0	74.25	3.94	27.70
Arizona	0.9	0.1	30	3	336.74	17.86	125.60
Arkansas	0.0	1.0	0	7	565.70	30.00	211.00
California	0.0	1.0	0	402	1535.54	81.44	572.74
Colorado	0.0	1.0	0	36	387.97	20.58	144.71
Connecticut	0.0	1.0	0	64	0.00	0.00	0.00
Delaware	0.0	1.0	0	9	60.57	3.21	22.59
District of Columbia	0.9	1.0	12	13	0.00	0.00	0.00
Florida	0.0	1.0	0	123	1170.41	62.07	436.55
Georgia	0.0	1.0	0	139	0.00	0.00	0.00
Hawaii	0.0	0.0	0	0	169.77	9.00	63.32
Idaho	0.0	0.0	0	0	242.68	12.87	90.52
Illinois	0.0	1.0	0	225	0.00	0.00	0.00
Indiana	0.0	1.0	0	31	1055.90	56.00	393.84
Iowa	0.0	0.0	0	0	761.31	40.38	283.96
Kansas	0.0	1.0	0	12	535.37	28.39	199.69
Kentucky	0.9	0.1	69	8	87.96	4.66	32.81
Louisiana	0.0	1.0	0	101	0.00	0.00	0.00
Maine	0.9	0.1	16	2	78.29	4.15	29.20
Maryland	0.9	0.1	70	8	235.64	12.50	87.89
Massachusetts	0.9	0.1	99	11	0.00	0.00	0.00
Michigan	0.0	1.0	0	296	0.00	0.00	0.00
Minnesota	0.0	0.0	0	0	1059.40	56.19	395.18
Mississippi	0.0	0.0	0	0	623.81	33.00	232.67
Missouri	0.0	1.0	0	59	682.74	36.21	254.66
Montana	0.0	0.0	0	0	220.40	12.11	83.19
Nebraska	0.9	0.1	0	0	411.34	21.82	153.43
Nevada	0.9	0.1	21	2	0.00	0.00	0.00
New Hampshire	0.9	0.1	18	2	0.00	0.00	0.00
New Jersey	0.0	1.0	0	155	0.00	0.00	0.00
New Mexico	0.9	0.1	7	1	323.55	17.16	120.68
New York	0.9	0.1	192	21	583.79	30.96	217.75
North Carolina	0.9	0.1	7	1	1442.54	76.51	538.05
North Dakota	0.0	0.0	0	0	177.39	9.41	66.17
Ohio	0.9	0.1	192	21	257.95	13.68	96.21
Oklahoma	0.0	1.0	0	22	667.57	35.40	249.00
Oregon	0.0	1.0	0	37	289.22	15.34	107.88
Pennsylvania	0.0	1.0	0	231	0.00	0.00	0.00
Rhode Island	0.9	0.1	16	2	0.00	0.00	0.00
South Carolina	0.0	1.0	0	75	0.00	0.00	0.00
South Dakota	0.0	0.0	0	0	199.48	10.58	74.40
Tennessee	0.9	0.1	105	12	0.00	0.00	0.00
Texas	0.0	1.0	0	166	2351.04	124.69	876.92
Utah	0.0	1.0	0	28	142.61	7.56	53.19
Vermont	0.9	0.1	0	0	127.19	6.75	47.44
Virginia	0.9	0.1	28	3	1030.18	54.64	384.25
Washington	0.0	1.0	0	44	503.65	26.71	187.86
West Virginia	0.9	0.1	7	1	367.34	19.48	137.01
Wisconsin	0.0	1.0	0	55	517.43	27.44	193.00
Wyoming	0.0	0.0	0	0	188.26	9.98	70.22
NATIONWIDE TOTAL			890	2,427	19,473	1,033	7,263

Table F-2. BULK TERMINAL STORAGE TANK BASELINE EMISSIONS (concluded)

STATE	AREAS UNCTRLD AT BASELINE WRKG LOSS FLOAT ROOF (Mg/yr)	AREAS UNCTRLD AT BASELINE WRKG LOSS FIXED ROOF (Mg/yr)	AREAS CNTRLD AT BASELINE STRG LOSS PRIM SEAL (Mg/yr)	AREAS CNTRLD AT BASELINE STRG LOSS SEC SEAL (Mg/yr)	AREAS CNTRLD AT BASELINE WRKG LOSS FLOAT ROOF (Mg/yr)	TOTAL STATE LOSSES (Mg/yr)	TOTAL BENZENE LOSSES (Mg/yr)
Alabama	0.00	0.00	0.00	467.99	2.03	470.03	
Alaska	0.12	100.41	0.00	0.00	0.00	286.42	
Arizona	0.57	455.38	449.81	16.70	0.73	1463.39	
Arkansas	0.95	764.99	0.00	35.39	0.15	1600.19	
California	2.58	2076.51	0.00	1994.82	0.67	6272.30	
Colorado	0.65	524.65	0.00	179.60	0.78	1259.01	
Connecticut	0.00	0.00	0.00	318.43	1.30	319.01	
Delaware	0.10	81.90	0.00	42.64	0.19	211.21	
District of Columbia	0.00	0.00	179.56	66.66	0.29	246.51	
Florida	1.97	1582.74	0.00	612.73	2.66	3069.13	
Georgia	0.00	0.00	0.00	692.37	3.01	695.30	
Hawaii	0.29	229.58	0.00	0.00	0.00	471.96	
Idaho	0.41	328.18	0.00	0.00	0.00	674.67	
Illinois	0.00	0.00	0.00	1118.25	4.06	1123.10	
Indiana	1.78	1427.89	0.00	151.70	0.66	3087.76	
Iowa	1.28	1029.53	0.00	0.00	0.00	2116.46	
Kansas	0.90	723.98	0.00	57.40	0.25	1545.99	
Kentucky	0.15	118.94	1027.00	38.13	1.66	1311.30	
Louisiana	0.00	0.00	0.00	500.63	2.10	502.00	
Maine	0.13	105.87	239.63	8.90	0.39	466.56	
Maryland	0.40	318.66	1034.52	38.41	1.67	1729.60	
Massachusetts	0.00	0.00	1472.03	54.65	2.37	1529.05	
Michigan	0.00	0.00	0.00	1021.78	4.44	1026.22	
Minnesota	1.78	1432.74	0.00	0.00	0.00	2945.37	
Mississippi	1.05	843.58	0.00	0.00	0.00	1734.19	
Missouri	1.15	923.27	0.00	294.66	1.20	2193.96	
Montana	0.38	308.86	0.00	0.00	0.00	634.95	
Nebraska	0.69	556.26	0.00	0.00	0.00	1143.54	
Nevada	0.00	0.00	313.54	11.64	0.51	325.60	
New Hampshire	0.00	0.00	267.28	9.92	0.43	277.63	
New Jersey	0.00	0.00	0.00	768.09	3.34	772.23	
New Mexico	0.54	437.53	110.45	4.10	0.10	1014.19	
New York	0.98	789.46	2858.71	106.13	4.61	4592.40	
North Carolina	2.43	1950.75	99.39	3.69	0.16	4113.52	
North Dakota	0.30	239.89	0.00	0.00	0.00	493.15	
Ohio	0.43	348.82	2846.58	105.68	4.59	3673.94	
Oklahoma	1.12	902.75	0.00	111.43	0.40	1967.77	
Oregon	0.49	391.12	0.00	184.39	0.00	989.23	
Pennsylvania	0.00	0.00	0.00	1149.25	4.99	1154.25	
Rhode Island	0.00	0.00	236.92	0.00	0.30	246.09	
South Carolina	0.00	0.00	0.00	373.09	1.62	375.51	
South Dakota	0.34	269.75	0.00	0.00	0.00	354.55	
Tennessee	0.00	0.00	1556.73	57.79	2.51	1617.03	
Texas	3.96	3179.31	0.00	826.34	3.59	7365.04	
Utah	0.24	192.85	0.00	98.33	0.43	495.21	
Vermont	0.21	172.00	0.00	0.00	0.00	353.58	
Virginia	1.73	1393.12	422.26	15.60	0.60	3302.54	
Washington	0.85	681.09	0.00	219.67	0.95	1620.79	
West Virginia	0.62	496.75	107.46	3.99	0.17	1132.02	
Wisconsin	0.87	699.72	0.00	276.58	1.20	1716.23	
Wyoming	0.32	254.58	0.00	0.00	0.00	523.36	
NATIONWIDE TOTAL	33	26,333	13,222	12,048	71	79,477	
					TOTAL TANK LOSSES (Mg/yr)	79,476.50	477

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Table F-3. BULK PLANT BASELINE EMISSIONS

STATE	1982 NATIONWIDE UNCONTROLLED THROUGHPUT (1000's liters)	1982 NATIONWIDE CONTROLLED THROUGHPUT (1000's liters)	1982 "27 AREAS" NONATTAINMENT UNCONTROLLED THROUGHPUT (1000's liters)	1982 "27 AREAS" NONATTAINMENT CONTROLLED THROUGHPUT (1000's liters)	1982 "11 AREAS" NONATTAINMENT UNCONTROLLED THROUGHPUT (1000's liters)	1982 "11 AREAS" NONATTAINMENT CONTROLLED THROUGHPUT (1000's liters)
Alabama	0	7,217,995	0	1,031,299	0	0
Alaska	519,677	0	0	0	0	0
Arizona	4,931,900	0	2,575,333	0	2,575,333	0
Arkansas	3,770,707	0	0	0	0	0
Pulaski	545,004	0	0	0	0	0
California	10,745,040	21,615,567	0	0	0	0
Bay Area	0	9,147,740	0	0	0	0
Colorado	2,715,332	2,771,240	0	2,771,240	0	0
Connecticut	0	4,911,193	0	0	0	0
Delaware	423,097	657,720	0	657,719	0	0
District of Columbia	0	0	0	0	0	0
Florida	8,191,527	0	0	0	0	0
Broward	9,450,263	0	0	0	0	0
Georgia	10,670,632	0	3,597,537	0	3,597,537	0
Hawaii	1,180,202	0	0	0	0	0
Idaho	1,690,519	0	0	0	0	0
Illinois	0	17,246,996	0	10,181,764	0	10,181,764
Indiana	9,729,747	0	0	1,195,772	0	919,641
Iowa	5,320,341	0	0	0	0	0
Kansas	4,619,092	0	0	0	0	0
Kentucky	0	6,495,052	0	1,005,622	0	0
Louisiana	0	7,721,294	0	618,594	0	0
Maine	1,920,020	0	0	0	0	0
Maryland	1,649,200	5,923,554	0	5,923,554	0	2,021,549
Massachusetts	0	8,420,661	0	5,963,641	0	0
Michigan	0	15,759,255	0	6,041,999	0	0
Minnesota	7,415,170	0	0	0	0	0
Mississippi	4,365,940	0	0	0	0	0
Missouri	6,126,023	3,196,943	0	3,196,943	0	3,196,943
Montana	1,590,519	0	0	0	0	0
Nebraska	2,070,560	0	0	0	0	0
Nevada	850,764	936,504	0	0	0	0
New Hampshire	1,530,400	0	0	0	0	0
New Jersey	0	11,850,791	0	11,850,791	0	11,850,791
New Mexico	2,096,865	0	0	0	0	0
New York	6,593,999	13,860,539	0	9,543,401	0	9,543,401
North Carolina	10,096,147	569,124	0	0	0	0
North Dakota	1,241,544	0	0	0	0	0
Ohio	1,805,332	16,299,183	0	0	0	0
Oklahoma	6,390,893	0	773,090	0	0	0
Oregon	2,024,229	2,043,932	0	0	0	0
Pennsylvania	0	17,725,227	0	8,209,752	0	4,479,627
Rhode Island	0	1,356,552	0	0	0	0
South Carolina	0	5,766,603	0	0	0	0
South Dakota	1,396,124	0	0	0	0	0
Tennessee	0	8,913,653	0	0	0	0
Texas	25,070,576	4,120,897	4,360,305	4,120,898	4,093,754	4,120,898
Utah	990,100	0	0	0	0	0
Davis	1,516,506	0	1,010,122	0	0	0
Vermont	565,232	0	0	0	0	0
Virginia	7,210,118	2,417,832	0	1,870,509	0	1,870,509
Washington	3,525,005	3,380,070	0	0	0	0
West Virginia	2,570,935	0	0	0	0	0
Wisconsin	2,933,810	4,952,563	0	2,274,000	0	0
Wyoming	1,317,589	0	0	0	0	0

Table F-3. BULK PLANT BASELINE EMISSIONS (continued)

STATE	1984 UNCONTROLLED THROUGHPUT IN SELECTED AREA (1000's liters)	1984 CONTROLLED THROUGHPUT IN SELECTED AREA (1000's liters)	% OF THROUGHPUT TO BULK PLANTS	UNCONTROLLED BULK PLANT THROUGHPUT IN SELECTED AREA (1000's liters)	CONTROLLED BULK PLANT THROUGHPUT IN SELECTED AREA (1000's liters)	UNCONTROLLED STRG TK BRTHNG LOSS (Mg/yr)	UNCONTROLLED STRG TK FILLING LOSS (Mg/yr)
Alabama	0	7,014,176	36%	0	2,525,103	0	0
Alaska	505,003	0	21%	106,051	0	24	124
Arizona	4,792,635	0	21%	1,006,453	0	230	1,181
Arkansas	3,664,231	0	64%	2,345,108	0	536	2,752
Pulaski	530,470	0	64%	339,501	0	70	398
California	10,442,403	21,005,196	15%	1,566,361	3,150,779	350	1,838
Bay Area	0	8,809,430	15%	0	1,333,414	0	0
Colorado	2,630,658	2,692,995	52%	1,372,102	1,400,357	313	1,610
Connecticut	0	4,772,513	8%	0	381,801	0	0
Delaware	411,927	639,148	20%	82,385	127,830	19	97
District of Columbia	0	0	0%	0	0	0	0
Florida	7,960,218	0	20%	1,592,044	0	364	1,868
Broward	9,183,410	0	20%	1,836,682	0	420	2,156
Georgia	10,377,093	0	31%	3,216,899	0	735	3,775
Hawaii	1,154,650	0	5%	57,733	0	13	68
Idaho	1,650,557	0	71%	1,171,895	0	268	1,375
Illinois	0	16,759,902	25%	0	4,189,996	0	0
Indiana	9,455,002	0	23%	2,174,651	0	497	2,552
Iowa	5,177,802	0	44%	2,278,268	0	520	2,674
Kansas	4,409,437	0	33%	1,481,514	0	330	1,739
Kentucky	0	6,312,425	45%	0	2,840,591	0	0
Louisiana	0	7,503,263	39%	0	2,926,273	0	0
Maine	1,865,003	0	23%	429,135	0	90	504
Maryland	1,602,638	5,756,287	15%	240,396	863,443	55	282
Massachusetts	0	8,190,656	10%	0	819,066	0	0
Michigan	0	15,314,252	20%	0	3,062,850	0	0
Minnesota	7,205,791	0	31%	2,233,795	0	510	2,622
Mississippi	4,242,664	0	59%	2,503,172	0	572	2,938
Missouri	5,953,039	3,106,669	46%	2,916,989	1,522,268	666	3,423
Montana	1,553,381	0	33%	512,616	0	117	602
Nebraska	2,797,276	0	74%	2,069,985	0	473	2,429
Nevada	834,515	910,059	29%	242,009	263,917	55	284
New Hampshire	1,487,185	0	75%	1,115,389	0	235	1,309
New Jersey	0	11,523,927	7%	0	806,675	0	0
New Mexico	2,815,065	0	52%	1,463,834	0	334	1,718
New York	6,407,800	13,469,151	8%	512,624	1,077,532	117	602
North Carolina	9,811,056	553,053	40%	3,924,422	221,221	896	4,606
North Dakota	1,206,486	0	33%	398,140	0	91	467
Ohio.	1,754,354	15,830,933	21%	368,414	3,326,176	84	432
Oklahoma.	6,210,430	0	22%	1,366,295	0	312	1,603
Oregon	1,967,070	2,763,626	33%	649,133	911,997	148	762
Pennsylvania	0	17,224,709	25%	0	4,306,177	0	0
Rhode Island	0	1,318,246	2%	0	26,365	0	0
South Carolina	0	5,603,768	34%	0	1,905,281	0	0
South Dakota	1,356,701	0	33%	447,711	0	102	525
Tennessee	0	8,661,953	31%	0	2,685,205	0	0
Texas	24,362,643	4,012,307	33%	8,039,672	1,324,061	1,837	9,435
Utah	559,916	0	57%	552,852	0	126	649
Davis	1,473,684	0	57%	840,000	0	44	227
Vermont	549,271	0	36%	197,738	0	45	232
Virginia	7,006,522	2,349,558	14%	900,913	328,938	224	1,151
Washington	3,425,467	3,292,399	24%	822,112	790,176	188	965
West Virginia	2,498,338	0	44%	1,099,269	0	251	1,290
Wisconsin	2,050,974	4,812,715	26%	741,253	1,251,306	169	870
Wyoming	1,280,383	0	59%	755,426	0	173	887
NATIONWIDE	175,922,029	200,291,398		56,050,939	44,360,799	12,656	65,023

Table F-3. BULK PLANT BASELINE EMISSIONS (continued)

STATE	UNCONTROLLED STRG TK DRAINING LOSS (Mg/yr)	UNCONTROLLED TK TRUCK SPLASH LOSS (Mg/yr)	UNCONTROLLED TK TRUCK SUBMGED LOSS (Mg/yr)	CONTROLLED STRG TANK BRTHING LOSS (Mg/yr)	CONTROLLED STRG TANK FILLING LOSS (Mg/yr)	CONTROLLED STRG TANK DRAINING LOSS (Mg/yr)	CONTROLLED TK TRUCK LOSS (Mg/yr)	TOTAL STATE LOSSES (Mg/yr)
Alabama	0	0	0	577	148	119	337	1,181
Alaska	50	51	64	0	0	0	0	314
Arizona	472	487	605	0	0	0	0	2,975
Arkansas	1,101	1,135	1,409	0	0	0	0	6,933
Pulaski	159	0	272	0	0	0	0	987
California	735	758	941	720	185	148	421	6,104
Bay Area	0	0	267	305	78	31	134	815
Colorado	644	664	824	320	82	66	187	4,711
Connecticut	0	0	0	87	22	18	51	179
Delaware	39	40	49	29	8	6	17	303
District of Columbia	0	0	0	0	0	0	0	0
Florida	747	770	956	0	0	0	0	4,706
Broward	862	0	1,471	0	0	0	0	4,909
Georgia	1,510	1,557	1,933	0	0	0	0	9,510
Hawaii	27	28	35	0	0	0	0	171
Idaho	550	567	704	0	0	0	0	3,464
Illinois	0	0	0	957	246	197	559	1,959
Indiana	1,021	1,052	1,306	0	0	0	0	6,429
Iowa	1,070	1,103	1,369	0	[illegible]	0	0	6,735
Kansas	695	717	890	0	0	0	0	4,300
Kentucky	0	0	0	649	167	133	379	1,328
Louisiana	0	0	0	660	172	137	391	1,368
Maine	201	200	258	0	0	0	0	1,269
Maryland	113	534	663	197	51	41	0	1,936
Massachusetts	0	0	0	187	48	38	109	383
Michigan	0	0	0	700	180	144	409	1,432
Minnesota	1,049	1,081	1,342	0	0	0	0	6,604
Mississippi	1,175	1,211	1,504	0	0	0	0	7,400
Missouri	1,369	1,412	1,752	348	89	71	203	9,335
Montana	241	248	308	0	0	0	0	1,515
Nebraska	972	1,002	1,244	0	0	0	0	6,119
Nevada	114	117	145	60	15	12	35	839
New Hampshire	524	540	670	0	0	0	0	3,297
New Jersey	0	0	0	184	47	38	108	377
New Mexico	687	708	879	0	0	0	0	4,327
New York	241	248	308	246	63	51	144	2,019
North Carolina	1,842	1,899	2,358	51	13	10	30	11,705
North Dakota	187	193	239	0	0	0	0	1,177
Ohio	173	178	221	760	195	156	444	2,644
Oklahoma	641	661	821	0	0	0	0	4,039
Oregon	305	314	396	200	54	43	122	2,345
Pennsylvania	0	0	0	984	253	292	575	2,013
Rhode Island	0	0	0	6	2	1	4	12
South Carolina	0	0	0	435	112	89	254	891
South Dakota	210	217	269	0	0	0	0	1,324
Tennessee	0	0	0	613	158	126	350	1,256
Texas	3,774	3,891	4,830	302	78	62	177	24,386
Utah	260	268	332	0	0	0	0	1,634
Davis	91	0	155	140	38	30	52	784
Vermont	93	96	119	0	0	0	0	585
Virginia	460	475	589	75	89	36	101	3,200
Washington	386	398	494	181	46	37	105	2,800
West Virginia	516	532	660	0	0	0	0	3,250
Wisconsin	340	359	445	286	73		167	2,718
Wyoming	355	366	454	0	0	0	0	2,233
NATIONWIDE	26,009	26,004	34,545	10,283	2,711	2,043	5,872	185,227

Table F-3. BULK PLANT BASELINE EMISSIONS (concluded)

STATE	BASE YEAR EMISSIONS AFTER IMPLEMENTATION OF NO EX. CONTROL OPTION STRG TANK BRTHING LOSS (Mg/yr)	STRG TANK FILLING LOSS (Mg/yr)	STRG TANK DRAINING LOSS (Mg/yr)	TK TRUCK LOSS (Mg/yr)	TOTAL STATE LOSSES (Mg/yr)	TOTAL BENZENE LOSSES (Mg/yr)
Alabama	577	148	119	337	1181	
Alaska	24	6	5	14	50	
Arizona	230	59	47	134	471	
Arkansas	536	138	110	313	1096	
Pulaski	78	20	16	45	159	
California	1,078	277	221	630	2206	
Bay Area	305	78	31	178	592	
Colorado	633	163	130	370	1296.	
Connecticut	87	22	18	51	179	
Delaware	48	12	10	28	98	
District of Columbia	0	0	0	0	0	
Florida	364	93	75	213	744	
Broward	420	108	86	245	859	
Georgia	735	189	151	429	1504	
Hawaii	13	3	3	8	27	
Idaho	268	69	55	156	548	
Illinois	957	246	197	559	1959	
Indiana	497	128	102	290	1017	
Iowa	520	134	107	304	1065	
Kansas	338	87	70	198	693	
Kentucky	649	167	133	379	1328	
Louisiana	668	172	137	391	1368	
Maine	98	25	20	57	201	
Maryland	252	65	52	147	516	
Massachusetts	187	48	38	109	383	
Michigan	700	180	144	409	1432	
Minnesota	510	131	105	298	1044	
Mississippi	572	147	118	334	1170	
Missouri	1,014	260	208	593	2076	
Montana	117	30	24	68	240	
Nebraska	473	121	97	276	968	
Nevada	116	30	24	68	237	
New Hampshire	255	65	52	149	522	
New Jersey	184	47	38	108	377	
New Mexico	334	86	69	195	684	
New York	363	93	75	212	744	
North Carolina	947	243	195	553	1938	
North Dakota	91	23	19	53	186	
Ohio	844	217	173	493	1727	
Oklahoma	312	80	64	182	639	
Oregon	357	92	73	208	730	
Pennsylvania	984	253	202	575	2013	
Rhode Island	6	2	1	4	12	
South Carolina	435	112	89	254	891	
South Dakota	102	26	21	60	209	
Tennessee	613	158	126	358	1256	
Texas	2,139	549	440	1,250	4378	
Utah	126	32	26	74	258	
Davis	192	49	39	112	393	
Vermont	45	12	9	26	92	
Virginia	299	77	61	175	612	
Washington	368	95	76	215	754	
West Virginia	251	65	52	147	514	
Wisconsin	455	117	94	266	932	
Wyoming	173	44	35	101	353	
NATIONWIDE	22,940	5,893	4,683	13,406	46,922	282

Table F-4. SERVICE STATION IN-USE BASELINE EMISSIONS

STATE	1982 NATIONWIDE UNCONTROLLED THROUGHPUT (1000's liters)	1982 NATIONWIDE CONTROLLED THROUGHPUT (1000's liters)	1982 ALL DESIGNATED NONATTAINMENT "UNCONTROLLED" THROUGHPUT (1000's liters)	1982 ALL DESIGNATED NONATTAINMENT "CONTROLLED" THROUGHPUT (1000's liters)	1982 "27 AREAS" NONATTAINMENT UNCONTROLLED THROUGHPUT (1000's liters)	1982 "27 AREAS" NONATTAINMENT CONTROLLED THROUGHPUT (1000's liters)	1982 "11 AREAS" NONATTAINMENT UNCONTROLLED THROUGHPUT (1000's liters)
Alabama	0	7,217,995	0	1,324,398	0	1,031,299	0
Alaska	519,677	0	0	0	0	0	0
Arizona	2,356,567	2,575,333	0	2,575,333	0	2,575,333	0
Arkansas	3,770,707	545,884	0	0	0	0	0
California	0	4,497,287	0	2,253,254	0	0	0
Bay Area	0	9,147,739	0	9,147,739	0	0	0
San Diego	0	2,984,120	0	2,984,120	0	0	0
South Coast	0	18,631,443	0	18,631,443	0	0	0
Other Stage II	0	6,248,552	0	6,248,552	0	0	0
Colorado	2,715,332	2,771,248	0	2,771.248	0	2.771.248	0
Connecticut	0	4,911,193	0	4,911,193	0	0	0
Delaware	423,897	657,719	0	657,719	0	657,719	0
District of Columbia	0	1,028,116	0	1,028,116	0	0	0
Florida	8,191,527	9,450,263	0	9,450,263	0	0	0
Georgia	10,678,632	0	3,864,595	0	3,597,537	0	3,597,537
Hawaii	1,188,202	0	0	0	0	0	0
Idaho	1,698,519	0	0	0	0	0	0
Illinois	0	17,246,996	0	10,074,016	0	10.181.764	0
Indiana	7,398,080	2,339,667	594,400	2,339,667	0	1,195,772	0
Iowa	5,328,341	0	0	0	0	0	0
Kansas	4,619,892	0	885,274	0	0	0	0
Kentucky	0	6,495,851	0	1,502,505	0	1,005,622	0
Louisiana	0	7,721,294	0	3,454,766	0	618,594	0
Maine	1,920,021	0	1,372,066	0	0	0	0
Maryland	1,649,208	5,923,554	0	5,630,390	0	5,923,554	0
Massachusetts	0	8,428,661	0	8,428,661	0	5,965,641	0
Michigan	0	15,759,252	0	13,617,090	0	6,041,999	0
Minnesota	7,415,178	0	0	0	0	0	0
Mississippi	4,365,948	0	0	0	0	0	0
Missouri	4,778,419	4,544,547	0	4,544,547	0	3,196,943	0
Montana	1,598,519	0	0	0	0	0	0
Nebraska	2,878,561	0	0	0	0	0	0
Nevada	265,654	1,529,614	0	936,504	0	0	0
New Hampshire	1,530,400	0	1,287,138	0	0	0	0
New Jersey	0	11,858,791	0	11,858,791	0	11,858,791	0
New Mexico	2,264,452	632,413	0	0	0	0	0
New York	11,090,033	9,364,505	218,947	7,531,760	181,165	9,362,235	181,165
North Carolina	10,095,995	569,124	0	569,124	0	0	0
North Dakota	1,241,544	0	0	0	0	0	0
Ohio	1,805,332	16,299,183	0	11,525,344	0	0	0
Oklahoma	6,390,893	0	773,098	0	773,098	0	0
Oregon	2,024,229	2,843,932	51,393	2,318,453	0	0	0
Pennsylvania	0	17,725,227	0	16,516,888	0	8,883,210	0
Rhode Island	0	1,356,552	0	1,356,552	0	0	0
Soutn Carolina	0	5,766,603	0	193,921	0	0	0
South Dakota	1,396,124	0	0	0	0	0	0
Tennessee	0	8,913,652	0	3,132,148	0	0	0
Texas	16,454,602	12,744,871	0	11,105,349	266,551	8,222,651	0
Utah	998,100	1,516,506	0	1,010,122	0	1,010,122	0
Vermont	890,183	0	0	0	0	0	0
Virginia	7,210,118	2,417,832	870,751	1,855,013	444,302	1,426,207	444,302
Washington	3,525,004	3,388,071	0	3,388,071	0	0	0
West Virginia	2,570,935	615,328	0	0	0	0	0
Wisconsin	2,933,818	4,952,563	0	2,455,432	0	2,274,800	0
Wyoming	1,317,589	0	0	0	0	0	0
NATIONWIDE	147,492,232	241,621,481	9,917,661	187,328,494	5,262,653	84,203,505	4,223,004

Table F-4. SERVICE STATION IN-USE BASELINE EMISSIONS (continued)

STATE	1982 "11 AREAS" NONATTAINMENT CONTROLLED THROUGHPUT (1000's liters)
Alabama	0
Alaska	0
Arizona	2,575,333
Arkansas	0
California	0
Bay Area	0
San Diego	0
South Coast	0
Other Stage II	0
Colorado	0
Connecticut	0
Delaware	0
District of Columbia	0
Florida	0
Georgia	0
Hawaii	0
Idaho	0
Illinois	10,181,764
Indiana	919,641
Iowa	0
Kansas	0
Kentucky	0
Louisiana	0
Maine	0
Maryland	2,021,549
Massachusetts	0
Michigan	0
Minnesota	0
Mississippi	0
Missouri	3,196,943
Montana	0
Nebraska	0
Nevada	0
New Hampshire	0
New Jersey	11,858,791
New Mexico	0
New York	9,362,235
North Carolina	0
North Dakota	0
Ohio	0
Oklahoma	0
Oregon	0
Pennsylvania	4,479,627
Rhode Island	0
South Carolina	0
South Dakota	0
Tennessee	0
Texas	8,222,651
Utah	0
Vermont	0
Virginia	1,426,207
Washington	0
West Virginia	0
Wisconsin	0
Wyoming	0
NATIONWIDE	54,244,742

Table F-4. SERVICE STATION IN-USE BASELINE EMISSIONS (continued)

STATE	1984 THROUGHPUT UNCONTROLLED FOR STAGE I (1000's liters)	1984 THROUGHPUT CONTROLLED FOR STAGE I (1000's liters)	UNCONTROLLED SERVICE STN TANK SPLASH LOSS (Mg/yr)	UNCONTROLLED SERVICE STN TANK SUBMERGED LOSS (Mg/yr)	SERVICE STN TANK FILLING LOSS (Mg/yr)	CONTROLLED SERVICE STN TANK BALANCED LOSS (Mg/yr)	SERVICE STATION TANKS STATE TOTAL (Mg/yr)
Alabama	0	7,016,285	0	0	842	344	1,186
Alaska	505,154	0	427	272	61	0	759
Arizona	2,290,712	2,503,364	1,937	1,232	575	123	3,867
Arkansas	3,665,333	530,629	3,100	2,541	504	0	6,145
California	0	4,371,608	0	0	525	214	739
Bay Area	0	8,892,101	0	0	149	435	585
San Diego	0	2,900,727	0	0	49	142	191
South Coast	0	18,110,779	0	0	384	807	1,191
Other Stage II	0	6,073,933	0	0	102	297	399
Colorado	2,639,451	2,693,804	2,232	1,419	640	132	4,423
Connecticut	0	4,773,947	0	0	573	234	807
Delaware	412,051	639,339	348	222	126	31	728
District of Columbia	0	999,385	0	0	46	49	95
Florida	7,962,611	9,186,171	6,734	4,281	2,058	735	13,808
Georgia	10,380,213	0	8,779	5,581	1,246	0	15,606
Hawaii	1,154,997	0	977	621	139	0	1,736
Idaho	1,651,053	0	1,396	888	198	0	2,482
Illinois	0	16,765,021	0	0	2,012	821	2,833
Indiana	7,183,561	2,274,204	6,075	3,862	1,135	111	11,184
Iowa	5,179,438	0	4,380	2,785	622	0	7,787
Kansas	4,490,787	0	3,798	2,414	539	0	6,751
Kentucky	0	6,314,321	0	0	758	309	1,067
Louisiana	0	7,505,519	0	0	901	1,081	1,981
Maine	1,866,365	0	1,578	1,003	224	0	2,806
Maryland	1,603,120	5,758,018	1,356	862	883	282	3,383
Massachusetts	0	8,193,118	0	0	983	401	1,384
Michigan	0	15,318,852	0	0	1,838	750	2,588
Minnesota	7,207,957	0	6,096	3,875	865	0	10,836
Mississippi	4,243,940	0	3,589	2,282	509	0	6,380
Missouri	4,644,084	4,417,547	3,928	2,497	1,087	216	7,730
Montana	1,553,848	0	1,314	835	186	0	2,336
Nebraska	2,798,118	0	2,367	1,504	336	0	4,207
Nevada	258,230	1,486,868	218	139	209	73	639
New Hampshire	1,487,632	0	1,258	800	179	0	2,237
New Jersey	0	11,527,391	0	0	1,383	564	1,948
New Mexico	2,201,171	614,740	1,862	1,183	338	85	3,468
New York	10,780,117	9,102,809	9,117	5,796	2,386	446	17,745
North Carolina	9,813,858	553,220	8,300	5,276	1,244	27	14,848
North Dakota	1,206,848	0	1,021	649	145	0	1,814
Ohio	1,754,881	15,843,695	1,484	944	2,112	776	5,315
Oklahoma	6,212,296	0	5,254	3,340	745	0	9,340
Oregon	1,967,661	2,764,457	1,664	1,058	568	135	3,425
Pennsylvania	0	17,229,887	0	0	2,068	844	2,911
Rhode Island	0	1,318,643	0	0	158	65	223
South Carolina	0	5,605,453	0	0	673	274	947
South Dakota	1,357,109	0	1,140	730	163	0	2,040
Tennessee	0	8,664,556	0	0	1,040	424	1,464
Texas	15,994,770	12,388,710	13,528	8,600	3,406	1,784	27,317
Utah	970,208	1,474,127	821	522	293	72	1,708
Vermont	865,306	0	732	465	104	0	1,301
Virginia	7,008,628	2,350,265	5,928	3,768	1,123	115	10,934
Washington	3,426,496	3,293,390	2,890	1,842	806	161	5,708
West Virginia	2,499,089	598,132	2,619	1,665	372	0	4,656
Wisconsin	2,851,831	4,814,161	2,412	1,533	920	236	5,101
Wyoming	1,280,768	0	1,083	689	154	0	1,926
NATIONWIDE	143,370,492	234,869,255	121,761	77,976	41,602	13,677	255,015

Table F-4. SERVICE STATION IN-USE BASELINE EMISSIONS (continued)

STATE	NA VEHICLE REFUELING & FILLING CONTROL LEVEL	NA VEHICLE REFUELING DISPLACEMENT LOSS (Mg/yr)	NA VEHICLE REFUELING SPILLAGE LOSS (Mg/yr)	NA VEHICLE REFUELING STATE TOTAL (Mg/yr)	ATT VEHICLE REFUELING DISPLACEMENT LOSS (Mg/yr)	ATT VEHICLE REFUELING SPILLAGE LOSS (Mg/yr)	ATT VEHICLE REFUELING STATE TOTAL (Mg/yr)
Alabama	0%	10,891	589	11,480	0	0	0
Alaska	0%	0	0	0	784	42	826
Arizona	0%	3,886	210	4,096	3,556	192	3,748
Arkansas	0%	824	45	868	5,689	308	5,997
California	0%	6,786	367	7,153	0	0	0
Bay Area	86%	1,932	747	2,679	0	0	0
San Diego	86%	630	244	874	0	0	0
South Coast	86%	3,936	1,521	5,457	0	0	0
Other Stage II	86%	1,320	510	1,830	0	0	0
Colorado	0%	4,181	226	4,408	4,097	222	4,319
Connecticut	0%	7,410	401	7,811	0	0	0
Delaware	0%	992	54	1,046	640	35	674
District of Columbia	62%	595	84	679	0	0	0
Florida	0%	14,259	772	15,031	12,360	669	13,029
Georgia	0%	0	0	0	16,113	872	16,984
Hawaii	0%	0	0	0	1,793	97	1,890
Idaho	0%	0	0	0	2,563	139	2,702
Illinois	0%	26,023	1,408	27,431	0	0	0
Indiana	0%	3,530	191	3,721	11,151	603	11,754
Iowa	0%	0	0	0	8,040	435	8,475
Kansas	0%	0	0	0	6,971	377	7,348
Kentucky	0%	9,801	530	10,332	0	0	0
Louisiana	0%	11,650	630	12,281	0	0	0
Maine	0%	0	0	0	2,897	157	3,054
Maryland	0%	8,938	484	9,421	2,488	135	2,623
Massachusetts	0%	12,718	688	13,406	0	0	0
Michigan	0%	23,778	1,287	25,065	0	0	0
Minnesota	0%	0	0	0	11,188	605	11,794
Mississippi	0%	0	0	0	6,588	356	6,944
Missouri	0%	6,857	371	7,228	7,210	390	7,600
Montana	0%	0	0	0	2,412	131	2,542
Nebraska	0%	0	0	0	4,343	235	4,578
Nevada	0%	2,308	125	2,433	401	22	423
New Hampshire	0%	0	0	0	2,309	125	2,434
New Jersey	0%	17,893	968	18,861	0	0	0
New Mexico	0%	954	52	1,006	3,417	185	3,602
New York	0%	14,130	765	14,894	16,733	906	17,639
North Carolina	0%	859	46	905	15,233	824	16,058
North Dakota	0%	0	0	0	1,873	101	1,975
Ohio	0%	24,593	1,331	25,924	2,724	147	2,871
Oklahoma	0%	0	0	0	9,643	522	10,165
Oregon	0%	4,291	232	4,523	3,054	165	3,220
Pennsylvania	0%	26,745	1,447	28,192	0	0	0
Rhode Island	0%	2,047	111	2,158	0	0	0
South Carolina	0%	8,701	471	9,172	0	0	0
South Dakota	0%	0	0	0	2,107	114	2,221
Tennessee	0%	13,449	728	14,177	0	0	0
Texas	0%	19,230	1,041	20,271	24,828	1,344	26,171
Utah	0%	2,288	124	2,412	1,506	81	1,587
Vermont	0%	0	0	0	1,343	73	1,416
Virginia	0%	3,648	197	3,846	10,879	589	11,468
Washington	0%	5,112	277	5,389	5,319	288	5,607
West Virginia	0%	928	50	979	3,879	210	4,089
Wisconsin	0%	7,473	404	7,877	4,427	240	4,666
Wyoming	0%	0	0	0	1,988	108	2,096
NATIONWIDE				335,318			234,587

Table F-4. SERVICE STATION IN-USE BASELINE EMISSIONS (concluded)

STATE	VEHICLE REFUELING STATE TOTAL (Mg/yr)
Alabzma	11,400
Alaska	827
Arizona	7,844
Arkansas	6,866
California	7,153
Bay Area	2,679
San Diego	874
South Coast	5,457
Other Stage II	1,830
Colorado	8,726
Connecticut	7,811
Delaware	1,720
District of Columbia	679
Florida	28,059
Georgia	16,984
Hawaii	1,890
Idaho	2,702
Illinois	27,431
Indiana	15,475
Iowa	8,475
Kansas	7,340
Kentucky	10,332
Louisiana	12,281
Maine	3,054
Maryland	12,045
Massachusetts	13,406
Michigan	25,065
Minnesota	11,794
Mississippi	6,944
Missouri	14,828
Montana	2,542
Nebraska	4,578
Nevada	2,855
New Hampshire	2,434
New Jersey	18,861
New Mexico	4,607
New York	32,533
North Carolina	16,963
North Dakota	1,975
Ohio	28,795
Oklahoma	10,165
Oregon	7,743
Pennsylvania	28,192
Rhode Island	2,158
South Carolina	9,172
South Dakota	2,221
Tennessee	14,177
Texas	46,442
Utah	3,999
Vermont	1,416
Virginia	15,313
Washington	10,995
West Virginia	5,068
Wisconsin	12,543
Wyoming	2,096
NATIONWIDE	569,905

APPENDIX G

NONATTAINMENT AREA DATA

APPENDIX G

NONATTAINMENT AREA DATA

As discussed in Section 2.3.3.4 of Chapter 2, regulatory strategies were evaluated for several groupings of ozone nonattainment areas. The tables in this appendix itemize the counties that are included in each area grouping. Population data came from the 1980 Bureau of Census Publications and gasoline consumption data came from county-by-county fuel consumption information presented in EPA's National Emission Data System (NEDS). A description of each of the nonattainment area groupings can be found in Section 2.3.3.4.

Table G-1 presents gasoline consumption and population data for six nonattainment area groupings. Counties included in each grouping are designated with an "x". Table G-2 summarizes the data for each grouping. Table G-3 compares nonattainment area groupings between the NA and NA* designations used in the July 1984 analysis, and the 27 area and 11 area groupings. Table G-4 presents the composition and gasoline consumption for the 61-area nonattainment area grouping.

Table G-1. COMPREHENSIVE NONATTAINMENT AREA DATA

	STATE	COUNTY	NONATTAINMENT AREA GROUPS: 27 AREAS	11 AREAS	URBAN NA (NA-1)	RURAL NA (NA-2)	URBAN JUST ATT (NA-3)	RURAL NA SELF-GEN. (NA-4)	1982 GASOLINE THRUPUT (1000 GAL/YR)	1980 POPULATION	SERVICE STATION EXEMPT. STAGE I	SERVICE STATION EXEMPT. STAGE II
1	ALABAMA	BALDWIN					X		48,702	78,556	NONE	UNC
2		ETOWAH				X			52,020	103,057	NONE	UNC
3		JEFFERSON	X		X				272,470	671,324	NONE	UNC
4		MOBILE					X		134,712	364,980	NONE	UNC
5		RUSSELL				X			25,417	47,356	NONE	UNC
6	ARIZONA	MARICOPA	X	X	X				688,465	1,509,052	UNC	UNC
7		PIMA					X		227,040	531,443	UNC	UNC
8	CALIFORNIA	ALAMEDA			X				498,261	1,105,379	(10k	(10k
9		BUTTE				X			73,353	143,851	(10k	UNC
10		CONTRA COSTA			X				304,044	656,380	(10k	(10k
11		EL DORADO			X				50,299	85,812	(10k	UNC
12		FRESNO			X				216,141	514,621	(10k	NONE
13		IMPERIAL				X			46,951	92,110	(10k	UNC
14		KERN			X				168,446	403,089	(10k	NONE
15		KINGS						X	36,440	73,738	(10k	NONE
16		LOS ANGELES			X				3,347,921	7,477,503	(10k	(10k
17		MADERA						X	36,511	63,116	(10k	NONE
18		MARIN			X				110,880	222,568	(10k	(10k
19		MERCED						X	68,736	134,560	(10k	NONE
20		MONTEREY			X				118,963	290,444	(10k	UNC
21		NAPA			X				34,004	99,199	(10k	(10k
22		ORANGE			X				933,206	1,932,709	(10k	(10k
23		PLACER			X				63,167	117,247	(10k	UNC
24		RIVERSIDE			X				290,651	663,166	(10k	(10k
25		SACRAMENTO			X				368,936	783,381	(10k	NONE
26		SAN BENITO			X				14,629	25,005	(10k	UNC
27		SAN BERNARDINO			X				368,464	895,016	(10k	(10k
28		SAN DIEGO			X				788,467	1,861,846	(10k	NONE
29		SAN FRANCISCO			X				247,113	678,974	(10k	(10k
30		SAN JOAQUIN						X	146,574	347,342	(10k	NONE
31		SAN MATEO			X				328,471	587,329	(10k	(10k
32A		SANTA BARBARA (w/ St.II)			X				66,990	149,347	(10k	NONE
32B		SANTA BARBARA (w/o St.II)			X				66,990	149,347	(10k	UNC
33		SANTA CLARA			X				625,680	1,295,071	(10k	(10k
34		SANTA CRUZ			X				82,586	188,141	(10k	UNC
35		SOLANO			X				96,772	235,203	(10k	(10k
36		SONOMA			X				167,587	299,681	(10k	(10k
37		STANISLAUS						X	144,773	265,900	(10k	NONE
38		SUTTER				X			29,463	52,246	(10k	UNC
39		TULARE						X	124,019	245,738	(10k	NONE
40		VENTURA			X				256,154	529,174	(10k	NONE
41		YOLO			X				47,093	113,374	(10k	NONE
42		YUBA				X			26,979	49,733	(10k	UNC
43	COLORADO	ADAMS	X		X				92,264	245,944	NONE	UNC
44		ARAPAHOE	X		X				91,659	293,621	(10k	UNC
45		BOULDER	X		X				94,927	189,625	(10k	UNC
46		DENVER	X		X				339,665	492,365	(10k	UNC
47		DOUGLAS	X		X				16,900	25,153	(10k	UNC
48		EL PASO					X		134,708	309,424	UNC	UNC
49		JEFFERSON	X		X				97,171	371,753	(10k	UNC
50	CONNECTICUT	ALL			X				1,257,541	3,107,576	(10k	UNC
51	DELAWARE	NEW CASTLE	X		X				173,778	398,115	NONE	UNC
52	DISTR. OF COL.	DISTRICT OF COLUMBIA			X				271,629	638,333	NONE	NONE
53	FLORIDA	BREVARD					X		124,032	272,959	UNC	UNC
54		BROWARD			X				402,935	1,018,200	(10k	UNC
55		DADE			X				646,936	1,625,781	(10k	UNC
56		DUVAL			X				253,167	571,003	(10k	UNC
57		ESCAMBIA					X		105,154	233,794	UNC	UNC
58		HILLSBOROUGH			X				277,927	646,960	(10k	UNC
59		ORANGE			X				249,719	471,016	(10k	UNC
60		PALM BEACH			X				240,311	576,863	(10k	UNC
61		PINELLAS			X				337,772	728,531	(10k	UNC
62		SANTA ROSA					X		34,530	55,988	UNC	UNC
63	GEORGIA	CLAYTON	X	X	X				64,127	150,357	UNC	UNC
64		COBB	X	X	X				171,621	297,718	UNC	UNC
65		COWETA	X	X		X			26,339	39,268	UNC	UNC
66		DEKALB	X	X	X				133,636	483,[illegible]	UNC	UNC
67		DOUGLAS	X	X		X			33,987	54,57[illegible]	UNC	UNC
68		FAYETTE	X	X		X			22,338	29,043	UNC	UNC
69		FULTON	X	X	X				338,216	589,904	UNC	UNC

Table G-1. COMPREHENSIVE NONATTAINMENT AREA DATA (continued)

	STATE	COUNTY	NONATTAINMENT AREA GROUPS						1982 GASOLINE THRUPUT (1000 GAL/YR)	1980 POPULATION	SERVICE STATION EXEMPT. STAGE I	SERVICE STATION EXEMPT. STAGE II
			27 AREAS	11 AREAS	URBAN NA (NA-1)	RURAL NA (NA-2)	URBAN JUST ATT (NA-3)	RURAL NA SELF-GEN. (NA-4)				
70		GWINNETT	X	X	X				96,638	166,903	UNC	UNC
71		HENRY	X	X		X			26,152	36,309	UNC	UNC
72		MUSCOGEE			X				78,557	170,108	UNC	UNC
73		PAULDING	X	X		X			15,289	26,110	UNC	UNC
74		ROCKDALE	X	X		X			22,089	36,747	UNC	UNC
75		RICHMOND					X		70,835	181,629	UNC	UNC
76	HAWAII	HONOLULU					X		210,049	762,565	UNC	UNC
77	ILLINOIS	BOONE					X		18,523	28,630	NONE	UNC
78		COOK	X	X	X				1,664,989	5,253,655	NONE	UNC
79		DuPAGE	X	X	X				290,643	658,835	NONE	UNC
80		HENRY					X		39,137	57,968	NONE	UNC
81		KANE	X	X	X				187,441	278,405	NONE	UNC
82		LAKE	X	X	X				150,522	440,372	NONE	UNC
83		MACOUPIN				X			28,297	49,384	NONE	UNC
84		MADISON	X	X	X				127,705	247,691	NONE	UNC
85		MONROE	X	X				X	8,908	20,117	NONE	UNC
86		McHENRY	X	X					48,764	147,897	NONE	UNC
87		PEORIA					X		79,128	200,466	NONE	UNC
88		ROCK ISLAND					X		79,313	165,968	NONE	UNC
89		ST. CLAIR	X	X	X				133,414	267,531	NONE	UNC
90		TAZEWELL					X		59,651	132,078	NONE	UNC
91		WILL	X	X	X				141,713	324,460	NONE	UNC
92		WINNEBAGO					X		98,584	250,884	NONE	UNC
93		WOODFORD					X		15,075	33,320	NONE	UNC
94	INDIANA	ALLEN					X		112,546	294,335	UNC	UNC
95		CLARK	X		X				44,144	88,838	<25K	UNC
96		ELKHART			X				68,040	137,330	UNC	UNC
97		FLOYD	X		X				28,810	61,169	<25K	UNC
98		LAKE	X	X	X				187,612	522,965	<25K	UNC
99		MARION			X				388,218	765,233	<25K	UNC
100		PORTER	X	X	X				55,338	119,816	<25K	UNC
101		ST. JOSEPH			X				88,993	241,617	<25K	UNC
102	IOWA	POLK					X		158,799	303,170	UNC	UNC
103		POTTAWATTAMIE					X		57,383	86,561	UNC	UNC
104		SCOTT					X		77,751	160,022	UNC	UNC
105	KANSAS	BUTLER					X		26,970	44,782	UNC	UNC
106		DOUGLAS				X			28,519	67,640	UNC	UNC
107		JOHNSON			X				122,150	270,269	UNC	UNC
108		SEDGWICK					X		161,558	366,531	UNC	UNC
109		WYANDOTTE			X				83,221	172,335	UNC	UNC
110	KENTUCKY	BOONE			X				25,443	45,842	NONE	UNC
111		BOYD				X			29,487	55,513	NONE	UNC
112		CAMPBELL			X				29,817	83,317	NONE	UNC
113		KENTON			X				47,370	137,058	NONE	UNC
114		JEFFERSON	X		X				265,606	685,004	NONE	UNC
115	LOUISIANA	ASCENSION				X			28,690	50,068	<25K	UNC
116		BEAUREGARD				X			17,453	29,692	<25K	UNC
117		BOSSIER				X			42,851	80,721	<25K	UNC
118		CADDO				X			113,763	252,358	<25K	UNC
119		CALCASIEU						X	74,388	167,223	<25K	UNC
120		EAST BATON ROUGE	X		X				152,941	366,191	<25K	UNC
121		GRANT				X			18,441	16,703	<25K	UNC
122		IBERVILLE				X			18,561	32,159	<25K	UNC
123		JEFFERSON			X				13,871	454,592	<25K	UNC
124		LAFAYETTE				X			83,072	150,017	<25K	UNC
125		LAFOURCHE				X			41,814	82,483	<25K	UNC
126		ORLEANS			X				182,666	557,515	<25K	UNC
127		POINTE COUPEE				X			13,197	24,045	<25K	UNC
128		ST. BERNARD			X				27,766	64,097	<25K	UNC
129		ST. CHARLES				X			22,619	37,259	<25K	UNC
130		ST. JAMES				X			11,143	21,495	<25K	UNC
131		ST. JOHN THE BAPTIST				X			13,999	31,924	<25K	UNC
132		ST. MARY				X			33,025	64,253	<25K	UNC
133		WEST BATON ROUGE	X			X			18,498	19,086	<25K	UNC
134	MAINE	ANDROSCOGGIN				X			37,489	99,657	UNC	UNC
135		CUMBERLAND				X			183,528	215,789	UNC	UNC
136		FRANKLIN				X			12,193	27,098	UNC	UNC
137		KENNEBEC				X			49,735	109,889	UNC	UNC
138		KNOX				X			12,270	32,941	UNC	UNC
139		LINCOLN				X			13,747	25,691	UNC	UNC

Table G-1. COMPREHENSIVE NONATTAINMENT AREA DATA (continued)

			NONATTAINMENT AREA GROUPS									
	STATE	COUNTY	27 AREAS	11 AREAS	URBAN NA (NA-1)	RURAL NA (NA-2)	URBAN JUST ATT (NA-3)	RURAL NA SELF-GEN (NA-4)	1982 GASOLINE THRUPUT (1000 GAL/YR)	1980 POPULATION	SERVICE STATION EXEMPT. STAGE I	SERVICE STATION EXEMPT. STAGE II
140		OXFORD				I			28,414	48,968	UNC	UNC
141		SAGADAHOC				I			11,460	28,795	UNC	UNC
142		SOMERSET				I			24,210	45,028	UNC	UNC
143		WALDO				I			13,466	28,414	UNC	UNC
144		YORK				I			63,975	139,666	UNC	UNC
145	MARYLAND	ANNE ARUNDEL	I		I				210,149	370,775	65%	UNC
146		BALTIMORE	I		I				87,750	655,615	65%	UNC
147		BALTIMORE CITY	I		I				465,150	786,775	65%	UNC
148		CARROLL	I		I				98,814	96,356	65%	UNC
149		HARFORD	I		I				82,935	145,930	65%	UNC
150		HOWARD	I		I				74,183	118,572	65%	UNC
151		MONTGOMERY	I	I	I				244,683	579,053	65%	UNC
152		PRINCE GEORGE'S	I	I	I				211,957	665,071	65%	UNC
153		WASHINGTON	I	I					77,454	113,086	65%	UNC
154	MASSACHUSETTS	ALL			I				2,226,[illegible]	3,737,037	NONE	UNC
155		CENTRAL MASS. APCD	I		Y				383,671		NONE	UNC
156		ESSEX (MB APCD)	I		Y					633,632	NONE	UNC
157		HAMPDEN (PV APCD)	I		Y					442,018	NONE	UNC
158		HAMPSHIRE (PV APCD)	I		Y					138,813	NONE	UNC
159		METRO. BOSTON APCD	I		Y				1,037,1[illegible]		NONE	UNC
160		MIDDLESEX (MB APCD)	I		Y					1,367,034	NONE	UNC
161		NORFOLK (MB APCD)	I		Y					606,587	NONE	UNC
162		PIONEER VALLEY APCD	I		Y				233,336		NONE	UNC
163		PLYMOUTH (MB APCD)	I		Y					405,437	NONE	UNC
164		SUFFOLK (MB APCD)	I		Y					650,142	NONE	UNC
165		WORCESTER (CM APCD)	I		Y					646,352	NONE	UNC
166	MICHIGAN	ALLEGAN				I			44,167	81,555	65%	UNC
167		BARRY				I			24,817	45,781	65%	UNC
168		BAY						I	56,379	119,881	65%	UNC
169		BERRIEN				I			102,817	171,276	65%	UNC
170		BRANCH				I			25,148	40,188	65%	UNC
171		CALHOUN				I			69,655	141,557	65%	UNC
172		CASS				I			25,877	49,499	65%	UNC
173		CLINTON			I				27,320	55,893	65%	UNC
174		EATON			I				37,736	88,337	65%	UNC
175		GENESEE			I				174,280	450,449	65%	UNC
176		GRATIOT				I			20,954	40,448	65%	UNC
177		HILLSDALE				I			24,989	42,071	65%	UNC
178		HURON				I			24,315	36,459	65%	UNC
179		INGHAM			I				111,084	275,520	65%	UNC
180		IONIA				I			27,019	51,815	65%	UNC
181		JACKSON				I			72,315	151,495	65%	UNC
182		KALAMAZOO				I			73,349	212,378	65%	UNC
183		KENT			I				175,119	444,506	65%	UNC
184		LAPEER				I			38,808	70,038	65%	UNC
185		LENAWEE				I			31,758	89,948	65%	UNC
186		LIVINGSTON				I			52,829	100,289	65%	UNC
187		MACOMB	I		I				255,945	694,600	65%	UNC
188		MARQUETTE				I			31,303	74,101	65%	UNC
189		MIDLAND						I	35,618	73,578	65%	UNC
190		MONROE					I		69,166	134,659	65%	UNC
191		MONTCALM				I			31,135	47,555	65%	UNC
192		MUSKEGON				I			76,327	157,589	65%	UNC
193		OAKLAND	I		I				466,178	1,011,793	65%	UNC
194		OTTAWA			I				55,545	157,174	65%	UNC
195		SAGINAW				I			111,446	228,059	65%	UNC
196		ST. CLAIR				I			75,401	138,802	65%	UNC
197		ST. JOSEPH				I			31,711	56,083	65%	UNC
198		SANILAC				I			25,561	40,789	65%	UNC
199		SHIAWASSEE				I			42,119	71,140	65%	UNC
200		TUSCOLA				I			36,370	56,961	65%	UNC
201		VAN BUREN				I			41,882	66,814	65%	UNC
202		WASHTENAW				I			96,250	264,748	65%	UNC
203		WAYNE	I		I				838,186	2,337,891	65%	UNC
204	MINNESOTA	ANOKA					I		127,348	195,998	UNC	UNC
205		DAKOTA					I		76,704	194,279	UNC	UNC
206		HENNEPIN					I		380,908	941,411	UNC	UNC
207		RAMSEY					I		186,811	459,784	UNC	UNC
208		WASHINGTON					I		53,648	113,571	UNC	UNC
209	MISSISSIPPI	HINDS					I		108,407	250,998	UNC	UNC

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Table G-1. COMPREHENSIVE NONATTAINMENT AREA DATA (continued)

	STATE	COUNTY	NONATTAINMENT AREA GROUPS 27 AREAS	11 AREAS	URBAN NA (NA-1)	RURAL NA (NA-2)	URBAN JUST ATT (NA-3)	RURAL NA SELF-GEN. (NA-4)	1982 GASOLINE THRUPUT (1000 GAL/YR)	1980 POPULATION	SERVICE STATION EXEMPT. STAGE I	SERVICE STATION EXEMPT. STAGE II
210		RANKIN					X		38,223	69,427	UNC	UNC
211	MISSOURI	CLAY			X				13,837	136,488	NONE	UNC
212		FRANKLIN	X	X	X				45,169	71,233	NONE	UNC
213		JACKSON			X				328,795	629,266	NONE	UNC
214		JEFFERSON	X	X	X				86,823	146,183	NONE	UNC
215		PLATTE			X				7,406	46,341	NONE	UNC
216		ST. CHARLES	X	X	X				88,647	144,107	NONE	UNC
217		ST. LOUIS	X	X	X				148,140	973,896	NONE	UNC
218		ST. LOUIS CITY	X	X	X				473,836	453,085	NONE	UNC
219	NEBRASKA	DOUGLAS					X		163,117	397,038	UNC	UNC
220		SARPY					X		32,612	86,015	UNC	UNC
221	NEVADA	CLARK			X				247,425	463,087	(10K	UNC
222	NEW HAMPSHIRE	BELKNAP				X			22,335	42,884	UNC	UNC
223		CHESHIRE				X			28,927	62,116	UNC	UNC
224		HILLSBOROUGH				X			117,744	276,608	UNC	UNC
225		MERRIMACK				X			34,106	98,302	UNC	UNC
226		ROCKINGHAM				X			99,162	190,345	UNC	UNC
227		STRAFFORD				X			24,687	85,408	UNC	UNC
228		SULLIVAN				X			13,002	36,063	UNC	UNC
229	NEW JERSEY	ALL	X	X	X				1,133,102	7,364,823	NONE	UNC
230		BERGEN			Y				379,349	845,385	NONE	UNC
231		BURLINGTON			Y				139,874	362,542	NONE	UNC
232		CAMDEN			Y				160,212	471,650	NONE	UNC
233		ESSEX			Y				273,060	851,116	NONE	UNC
234		GLOUCESTER			Y				94,540	199,917	NONE	UNC
235		HUDSON			Y				152,461	556,972	NONE	UNC
236		MERCER			Y				133,761	307,863	NONE	UNC
237		MIDDLESEX			Y				247,290	595,893	NONE	UNC
238		MONMOUTH			Y				209,687	503,173	NONE	UNC
239		MORRIS			Y				165,152	407,630	NONE	UNC
240		PASSAIC			Y				165,120	447,585	NONE	UNC
241		SOMERSET			Y				76,955	203,129	NONE	UNC
242		UNION			Y				221,776	504,094	NONE	UNC
243	NEW MEXICO	BERNALILLO					X		167,004	419,700	NONE	UNC
244	NEW YORK	BRONX	X	X	X				140,952	1,168,972	(10K	UNC
245		KINGS	X	X	X				276,753	2,230,936	(10K	UNC
246		LIVINGSTON					X		29,940	57,006	UNC	UNC
247		MADISON					X		33,971	65,150	UNC	UNC
248		MONROE					X		249,381	702,238	UNC	UNC
249		NASSAU	X	X	X				548,687	1,321,582	(10K	UNC
250		NEW YORK	X	X	X				120,637	1,428,285	(10K	UNC
251		ONONDAGA					X		156,520	463,920	UNC	UNC
252		ORLEANS					X		20,400	38,496	UNC	UNC
253		OSWEGO					X		54,035	113,901	UNC	UNC
254		PUTNAM	X	X					47,864	77,193	UNC	UNC
255		QUEENS	X	X	X				382,606	1,891,325	(10K	UNC
256		RICHMOND	X	X	X				100,191	352,121	(10K	UNC
257		ROCKLAND	X	X	X				98,700	259,530	(10K	UNC
258		SCHENECTADY			X				57,846	149,946	UNC	UNC
259		SUFFOLK	X	X					482,613	1,284,231	(10K	UNC
260		WAYNE					X		47,617	84,581	UNC	UNC
261		WESTCHESTER	X	X	X				321,343	866,599	(10K	UNC
262	NORTH CAROLINA	CUMBERLAND					X		77,330	247,160	UNC	UNC
263		MECKLENBURG			X				150,363	404,270	(10K	UNC
264		WAKE					X		120,091	301,327	UNC	UNC
265	OHIO	ASHTABULA				X			48,558	104,215	(25K	UNC
266		BUTLER			X				94,289	258,787	(25K	UNC
267		CLARK				X			74,393	150,236	(25K	UNC
268		CLERMONT			X				53,967	128,483	(25K	UNC
269		CLINTON				X			21,420	34,603	(25K	UNC
270		COLUMBIANA				X			58,074	113,572	(25K	UNC
271		CUYAHOGA			X				546,964	1,498,400	(25K	UNC
272		DELAWARE			X				20,518	53,840	(25K	UNC
273		FRANKLIN			X				330,065	869,132	(25K	UNC
274		GEAUGA				X			35,133	74,474	(25K	UNC
275		GREENE			X				52,719	129,769	(25K	UNC
276		HAMILTON			X				345,136	873,224	(25K	UNC
277		JEFFERSON						X	45,727	91,564	(25K	UNC
278		LAKE			X				77,423	212,801	(25K	UNC
279		LICKING				X			55,214	120,981	(25K	UNC

Table G-1. COMPREHENSIVE NONATTAINMENT AREA DATA (continued)

	STATE	COUNTY	NONATTAINMENT AREA GROUPS: 27 AREAS	11 AREAS	URBAN NA (NA-1)	RURAL NA (NA-2)	URBAN JUST ATT (NA-3)	RURAL NA SELF-GEN. (NA-4)	1982 GASOLINE THRUPUT (1000 GAL/YR)	1980 POPULATION	SERVICE STATION EXEMPT. STAGE I	SERVICE STATION EXEMPT. STAGE II
280		LORAIN			X				91,127	274,909	<25k	UNC
281		LUCAS					X		174,280	471,741	<25k	UNC
282		MAHONING			X				116,347	289,487	<25k	UNC
283		MIAMI			X				51,275	90,381	<25k	UNC
284		MONTGOMERY			X				236,001	571,697	<25k	UNC
285		PORTAGE			X				59,346	135,856	<25k	UNC
286		PREBLE			X				23,447	38,223	<25k	UNC
287		STARK			X				204,832	378,823	<25k	UNC
288		SUMMIT			X				289,515	524,472	<25k	UNC
289		TRUMBULL			X				121,055	241,863	<25k	UNC
290		WARREN			X				52,438	99,276	<25k	UNC
291		WOOD					X		46,631	107,372	<25k	UNC
292	OKLAHOMA	CANADIAN					X		24,733	56,452	UNC	UNC
293		CLEVELAND					X		58,286	133,173	UNC	UNC
294		OKLAHOMA					X		249,819	568,933	NONE	UNC
295		TULSA	X		X				204,253	470,593	NONE	UNC
296	OREGON	CLACKAMUS			X				87,808	241,919	<10k	UNC
297		JACKSON				X			64,330	132,456	<10k	UNC
298		MARION				X			113,477	204,692	<10k	UNC
299		MULTNOMAH			X				252,836	562,640	<10k	UNC
300		POLK				X			13,578	45,203	UNC	UNC
301		WASHINGTON			X				98,856	245,808	<10k	UNC
302	PENNSYLVANIA	ADAMS				X			35,929	68,292	NONE	UNC
303		ALLEGHENY	X		X				478,290	1,450,085	NONE	UNC
304		ARMSTRONG	X		X				47,015	77,768	NONE	UNC
305		BEAVER	X		X				68,393	204,441	NONE	UNC
306		BEDFORD				X			26,042	46,784	NONE	UNC
307		BERKS				X			144,040	312,509	NONE	UNC
308		BLAIR						X	57,991	136,621	NONE	UNC
309		BUCKS	X	X	X				176,612	479,211	NONE	UNC
310		BUTLER	X		X				76,618	147,912	NONE	UNC
311		CAMBRIA				X			77,040	183,263	NONE	UNC
312		CARBON				X			24,356	53,285	NONE	UNC
313		CENTRE				X			48,246	112,760	NONE	UNC
314		CHESTER	X	X	X				162,189	316,660	NONE	UNC
315		CLEARFIELD				X			40,713	83,578	NONE	UNC
316		CRAWFORD				X			42,465	88,869	NONE	UNC
317		CUMBERLAND			X				91,961	178,541	NONE	UNC
318		DAUPHIN			X				88,069	232,317	NONE	UNC
319		DELAWARE	X	X	X				191,584	555,007	NONE	UNC
320		ERIE				X			91,173	279,780	NONE	UNC
321		FAYETTE				X			83,682	159,417	NONE	UNC
322		FRANKLIN				X			58,128	113,629	NONE	UNC
323		GREENE				X			21,771	40,476	NONE	UNC
324		INDIANA				X			43,929	92,281	NONE	UNC
325		JUNIATA				X			10,859	19,188	NONE	UNC
326		LACKAWANNA	X		X				67,798	227,908	NONE	UNC
327		LANCASTER						X	158,787	362,346	NONE	UNC
328		LAWRENCE				X			48,151	107,150	NONE	UNC
329		LEBANON				X			58,086	108,582	NONE	UNC
330		LEHIGH	X		X				93,001	272,349	NONE	UNC
331		LUZERNE	X		X				118,133	343,079	NONE	UNC
332		LYCOMING				X			58,669	118,416	NONE	UNC
333		MERCER				X			55,811	128,299	NONE	UNC
334		MONROE				X			37,837	69,409	NONE	UNC
335		MONTGOMERY	X	X	X				254,286	643,621	NONE	UNC
336		NORTHAMPTON	X		X				117,612	225,418	NONE	UNC
337		NORTHUMBERLAND				X			42,559	100,381	NONE	UNC
338		PERRY			X				21,629	35,718	NONE	UNC
339		PHILADELPHIA	X	X	X				397,930	1,688,210	NONE	UNC
340		PIKE				X			10,263	18,271	NONE	UNC
341		SCHUYLKILL				X			69,759	160,630	NONE	UNC
342		SNYDER				X			18,362	33,584	NONE	UNC
343		SOMERSET				X			46,488	81,243	NONE	UNC
344		SUSQUEHANNA				X			20,969	37,876	NONE	UNC
345		WARREN				X			22,400	47,449	NONE	UNC
346		WASHINGTON	X		X				114,155	217,074	NONE	UNC
347		WAYNE				X			23,470	35,237	NONE	UNC
348		WESTMORELAND	X		X				168,346	392,294	NONE	UNC
349		WYOMING				X			15,728	26,433	NONE	UNC

Table G-1. COMPREHENSIVE NONATTAINMENT AREA DATA (concluded)

	STATE	COUNTY	NONATTAINMENT AREA GROUPS						1982 GASOLINE THRUPUT (1000 GAL/YR)	1980 POPULATION	SERVICE STATION EXEMPT. STAGE I	SERVICE STATION EXEMPT. STAGE II
			27 AREAS	11 AREAS	URBAN NA (NA-1)	RURAL NA (NA-2)	URBAN JUST ATT (NA-3)	RURAL NA SELF-GEN. (NA-4)				
350		YORK						X	143,944	312,963	NONE	UNC
351	RHODE ISLAND	BRISTOL				X			11,749	46,942	NONE	UNC
352		KENT				X			61,842	154,163	NONE	UNC
353		NEWPORT				X			29,697	81,383	NONE	UNC
354		PROVIDENCE			X				195,687	571,349	NONE	UNC
355		WASHINGTON				X			59,427	93,317	NONE	UNC
356	SOUTH CAROLINA	AIKEN					X		68,335	105,625	NONE	UNC
357		BERKELEY					X		28,280	94,727	NONE	UNC
358		CHARLESTON					X		98,671	276,974	NONE	UNC
359		GREENVILLE					X		151,953	287,913	NONE	UNC
360		PICKENS					X		45,111	79,292	NONE	UNC
361		YORK				X			51,234	106,720	NONE	UNC
362	TENNESSEE	BRADLEY				X			33,655	67,547	(25k	UNC
363		DAVIDSON			X				208,711	447,811	(25k	UNC
364		HAMILTON			X				121,985	287,740	(25k	UNC
365		ROANE				X			27,290	48,425	(25k	UNC
366		RUTHERFORD				X			39,597	84,058	(25k	UNC
367		SHELBY			X				284,425	777,113	(25k	UNC
368		SUMNER				X			42,220	85,790	(25k	UNC
369		WILLIAMSON				X			36,181	58,108	(25k	UNC
370		WILSON				X			31,524	56,064	(25k	UNC
371	TEXAS	BRAZORIA				X			73,262	169,587	(10k	UNC
372		DALLAS	X	X	X				673,196	1,556,390	(10k	UNC
373		DENTON	X						78,423	143,126	UNC	UNC
374		EL PASO			X				174,389	479,899	(10k	UNC
375		GALVESTON				X			91,866	195,940	(10k	UNC
376		GREGG						X	55,781	99,487	(10k	UNC
377		HARRIS	X	X	X				1,090,858	2,409,547	(10k	UNC
378		JEFFERSON						X	136,290	250,938	(10k	UNC
379		NUECES			X				143,968	268,215	(10k	UNC
380		ORANGE						X	47,700	83,838	(10k	UNC
381		TARRANT	X	X	X				400,377	860,880	(10k	UNC
382		VICTORIA				X			38,425	68,807	(10k	UNC
383	UTAH	DAVIS	X		X				31,890	146,540	NONE	UNC
384		SALT LAKE	X		X				214,985	619,066	NONE	UNC
385		WEBER					X		65,276	144,616	NONE	UNC
386	VIRGINIA	ALEXANDRIA CITY	X	X	X				96,127	103,217	(25k	UNC
387		ARLINGTON	X	X	X				67,934	152,599	(25k	UNC
388		CHESAPEAKE CITY					X		41,272	114,486	UNC	UNC
389		CHESTERFIELD			X				35,106	141,372	(25k	UNC
390		FAIRFAX	X	X	X				197,318	596,901	(25k	UNC
391		FAIRFAX CITY	X	X	X				15,426	19,390	(25k	UNC
392		FALLS CHURCH CITY	X	X	X					9,515	(25k	UNC
393		HAMPTON CITY					X		49,603	122,617	(25k	UNC
394		HENRICO			X				78,185	180,735	(25k	UNC
395		LOUDOUN	X	X	X				35,759	57,427	UNC	UNC
396		MANASSAS CITY	X	X	X					15,438	(25k	UNC
397		MANASSAS PARK CITY	X	X	X					6,524	(25k	UNC
398		NEWPORT NEWS CITY					X		53,000	144,903	(25k	UNC
399		NORFOLK CITY					X		81,374	266,979	(25k	UNC
400		PORTSMOUTH CITY					X		35,174	104,577	UNC	UNC
401		PRINCE WILLIAM	X	X	X				81,626	144,703	UNC	UNC
402		RICHMOND CITY			X				112,668	219,214	UNC	UNC
403		VIRGINIA BEACH CITY					X		93,238	262,199	UNC	UNC
404		YORK					X		10,661	35,463	UNC	UNC
405	WASHINGTON	CLARK			X				76,320	192,227	(25k	UNC
406		KING			X				523,007	1,269,749	(25k	UNC
407		PIERCE			X				176,794	485,643	(25k	UNC
408		SNOHOMISH			X				118,330	337,720	(25k	UNC
409		SPOKANE					X		149,326	341,835	UNC	UNC
410	WISCONSIN	DANE					X		119,388	323,545	NONE	UNC
411		KENOSHA	X		X				55,552	123,137	NONE	UNC
412		MILWAUKEE	X		X				333,630	964,988	NONE	UNC
413		OZAUKEE	X		X				34,770	66,981	NONE	UNC
414		RACINE	X		X				66,407	173,132	NONE	UNC
415		SHEBOYGAN				X			47,723	100,935	NONE	UNC
416		WAUKESHA	X		X				110,637	280,326	NONE	UNC

Table G-2. DATA FOR NA AREA GROUPINGS

1982 THRUPUT & 1980 POPULATION FOR NONATTAINMENT GROUPINGS:	THRUPUT (1000 GAL)	POPULATION (1000)	% OF U.S. THRUPUT	% OF U.S. POPULATION	NO. OF COUNTIES
URBAN AREAS DESIGNATED NONATTAINMENT (NA-1):					
ALL AREAS	45,358,825	114,059	44.17%	50.35%	224
AREAS WITHOUT STAGE II CONTROLS	35,865,747	92,918	34.92%	41.02%	203
AREAS WITHOUT STAGE I OR STAGE II CONTROLS	2,116,718	4,518	2.06%	1.99%	14
ALL CALIFORNIA AREAS	9,638,004	21,359	9.38%	9.43%	26
CALIFORNIA AREAS WITHOUT STAGE II CONTROLS	416,556	856	0.41%	0.38%	6
ALL DISTRICT OF COLUMBIA AREAS (ALL WITH STAGE II)	271,629	638	0.26%	0.28%	1
27 NONATTAINMENT AREAS ;ALL W/O STAGE II	22,921,406	62,244	22.32%	27.48%	115
11 NONATTAINMENT AREAS ;ALL W/O STAGE II	14,634,588	40,843	14.25%	18.03%	68
RURAL AREAS DESIGNATED NONATTAINMENT (NA-2):					
ALL AREAS	5,375,140	11,022	5.23%	4.87%	125
AREAS WITHOUT STAGE II CONTROLS	5,375,140	11,022	5.23%	4.87%	125
AREAS WITHOUT STAGE I OR STAGE II CONTROLS	890,695	1,929	0.87%	0.85%	26
ALL CALIFORNIA AREAS	178,756	338	0.17%	0.15%	4
CALIFORNIA AREAS WITHOUT STAGE II CONTROLS	178,756	338	0.17%	0.15%	4
ALL DISTRICT OF COLUMBIA AREAS (ALL WITH STAGE II)	0	0	0.00%	0.00%	0
27 NONATTAINMENT AREAS ;ALL W/O STAGE II	156,526	241	0.15%	0.11%	7
11 NONATTAINMENT AREAS ;ALL W/O STAGE II	146,034	222	0.14%	0.10%	6
MAJOR URBAN AREAS JUST BARELY ATTAINMENT (NA-3):					
ALL AREAS	5,909,643	14,296	5.75%	6.31%	62
AREAS WITHOUT STAGE II CONTROLS	5,909,643	14,296	5.75%	6.31%	62
AREAS WITHOUT STAGE I OR STAGE II CONTROLS	3,876,169	9,434	3.77%	4.16%	38
ALL CALIFORNIA AREAS	0	0	0.00%	0.00%	0
CALIFORNIA AREAS WITHOUT STAGE II CONTROLS	0	0	0.00%	0.00%	0
ALL DISTRICT OF COLUMBIA AREAS (ALL WITH STAGE II)	0	0	0.00%	0.00%	0
27 NONATTAINMENT AREAS ;ALL W/O STAGE II	0	0	0.00%	0.00%	0
11 NONATTAINMENT AREAS ;ALL W/O STAGE II	0	0	0.00%	0.00%	0
RURAL SELF-GENERATING NONATTAINMENT AREAS (NA-4):					
ALL AREAS	1,378,626	2,849	1.34%	1.26%	17
AREAS WITHOUT STAGE II CONTROLS	821,513	1,719	0.80%	0.76%	11
AREAS WITHOUT STAGE I OR STAGE II CONTROLS	0	0	0.00%	0.00%	0
ALL CALIFORNIA AREAS	557,113	1,130	0.54%	0.50%	6
CALIFORNIA AREAS WITHOUT STAGE II CONTROLS	0	0	0.00%	0.00%	0
ALL DISTRICT OF COLUMBIA AREAS (ALL WITH STAGE II)	0	0	0.00%	0.00%	0
27 NONATTAINMENT AREAS ;ALL W/O STAGE II	8,908	9	0.01%	0.00%	1
11 NONATTAINMENT AREAS ;ALL W/O STAGE II	8,908	9	0.01%	0.00%	1
ALL DESIGNATED NA & URBAN W/ 0.1 DESIGN VALUE (NA-1+2+3+4):					
ALL AREAS	58,022,234	142,226	56.5%	62.8%	428
AREAS WITHOUT STAGE II CONTROLS	47,972,043	119,954	46.7%	52.9%	401
AREAS WITHOUT STAGE I OR STAGE II CONTROLS	6,883,582	15,881	6.7%	7.0%	78
ALL CALIFORNIA AREAS	10,373,873	22,827	10.1%	10.1%	36
CALIFORNIA AREAS WITHOUT STAGE II CONTROLS	595,312	1,194	0.6%	0.5%	10
ALL DISTRICT OF COLUMBIA AREAS (ALL WITH STAGE II)	271,629	638	0.3%	0.3%	1
27 NONATTAINMENT AREAS ;ALL W/O STAGE II	23,086,840	62,494	22.5%	27.6%	123
11 NONATTAINMENT AREAS ;ALL W/O STAGE II	14,789,530	41,074	14.4%	18.1%	75
ALL DESIGNATED NA (URBAN & RURAL) (NA-1+2+4):					
ALL AREAS	52,112,591	127,930	50.7%	56.5%	366
AREAS WITHOUT STAGE II CONTROLS	42,062,400	105,658	41.0%	46.6%	339
AREAS WITHOUT STAGE I OR STAGE II CONTROLS	3,007,413	6,447	2.9%	2.8%	40
ALL CALIFORNIA AREAS	10,373,873	22,827	10.1%	10.1%	36
CALIFORNIA AREAS WITHOUT STAGE II CONTROLS	595,312	1,194	0.6%	0.5%	10
ALL DISTRICT OF COLUMBIA AREAS (ALL WITH STAGE II)	271,629	638	0.3%	0.3%	1
27 NONATTAINMENT AREAS ;ALL W/O STAGE II	23,086,840	62,494	22.5%	27.6%	123
11 NONATTAINMENT AREAS ;ALL W/O STAGE II	14,789,530	41,074	14.4%	18.1%	75
ALL DESIGNATED URBAN (& RURAL SELF-GENERATING) NA AREAS (NA-1+4):					
ALL AREAS	46,737,451	116,908	45.5%	51.6%	241
AREAS WITHOUT STAGE II CONTROLS	36,687,260	94,636	35.7%	41.8%	214
AREAS WITHOUT STAGE I OR STAGE II CONTROLS	2,116,718	4,518	2.1%	2.0%	14
ALL CALIFORNIA AREAS	10,195,117	22,489	9.9%	9.9%	32
CALIFORNIA AREAS WITHOUT STAGE II CONTROLS	416,556	856	0.4%	0.4%	6
ALL DISTRICT OF COLUMBIA AREAS (ALL WITH STAGE II)	271,629	638	0.3%	0.3%	1
27 NONATTAINMENT AREAS ;ALL W/O STAGE II	22,930,314	62,253	22.3%	27.5%	116
11 NONATTAINMENT AREAS ;ALL W/O STAGE II	14,643,436	40,852	14.3%	18.0%	69

Table G-3. NONATTAINMENT AREA DATA

STATE	METROPOLITAN AREA	COUNTY	POPULATION RANGE	SERVICE STATION STAGE I EXEMPT.	NONATTAINMENT AREA GROUPS ALL OBD	SELECTED OBDs	27 AREAS	11 AREAS	1982 BASELINE THRUPUT (1000 GAL/YR)	1980 POPULATION
ALABAMA	BIRMINGHAM	JEFFERSON	250M-1MM	NONE	X		X		272,470	671,324
ARIZONA	PHOENIX	MARICOPA	1MM-3MM	NONE	X		X	X	580,445	1,509,052
CALIFORNIA	NORTH CENTRAL COAST	MONTEREY	250M-1MM	(10k	X				110,965	290,444
		SAN BENITO	)25M IN CO.	(10k	X				14,630	25,005
		SANTA CRUZ	(250M IN SMSA	(10k	X				82,596	188,141
COLORADO	DENVER	ADAMS	1MM-3MM	NONE	X		X		92,264	245,944
		ARAPAHOE	1MM-3MM	NONE	X		X		91,630	293,621
		BOULDER	1MM-3MM	NONE	X		X		94,527	189,625
		DENVER	1MM-3MM	NONE	X		X		339,665	492,365
		DOUGLAS	1MM-3MM	NONE	X		X		16,900	25,153
		JEFFERSON	1MM-3MM	NONE	X		X		57,171	371,753
CONNECTICUT	STATEWIDE	ALL		(10k	X				1,297,541	
		ALL	1MM-3MM	(10k	X					1,651,606
		ALL	250M-1MM	(10k	X					1,550,400
		ALL	(250M IN SMSA	(10k	X					238,409
		ALL	)25M IN CO.	(10k	X					249,081
	NEW YORK SCSA	FAIRFIELD	250M-1MM	(10k		X			319,799	807,143
DELAWARE	WILMINGTON	NEW CASTLE	250M-1MM	NONE	X		X		173,779	398,115
FLORIDA	MIAMI	BROWARD	1MM-3MM	(25k	X				482,595	1,018,200
		DADE	1MM-3MM	(25k	X				646,936	1,625,781
		PALM BEACH	250M-1MM	(25k	X				248,311	576,863
GEORGIA	ATLANTA	CLAYTON	1MM-3MM	UNC	X		X	X	64,127	150,357
		COBB	1MM-3MM	UNC	X		X	X	171,621	297,718
		COWETA	)25M IN CO.	UNC	X		X	X	26,339	39,268
		DEKALB	1MM-3MM	UNC	X		X	X	133,636	483,024
		DOUGLAS	1MM-3MM	UNC	X		X	X	32,987	54,573
		FAYETTE	1MM-3MM	UNC	X		X	X	22,330	29,043
		FULTON	1MM-3MM	UNC	X		X	X	338,216	589,904
		GWINNETT	1MM-3MM	UNC	X		X	X	95,838	166,903
		HENRY	1MM-3MM	UNC	X		X	X	26,152	36,309
		PAULDING	1MM-3MM	UNC	X		X	X	15,209	26,119
		ROCKDALE	1MM-3MM	UNC	X		X	X	22,009	36,747
ILLINOIS	CHICAGO	COOK	)3MM IN SMSA	NONE	X	X	X	X	1,664,920	5,253,655
		DuPAGE	)3MM IN SMSA	NONE	X	X	X	X	298,643	658,835
		KANE	)3MM IN SMSA	NONE	X	X	X	X	187,441	278,405
		LAKE	)3MM IN SMSA	NONE	X	X	X	X	150,522	440,372
		McHENRY	)3MM IN SMSA	NONE	X	X	X	X	48,764	147,897
		WILL	)3MM IN SMSA	NONE	X	X	X	X	141,713	324,460
	ST. LOUIS	MADISON	1MM-3MM	NONE	X		X	X	127,785	247,691
		MONROE	1MM-3MM	NONE	X		X	X	8,900	20,117
		ST. CLAIR	1MM-3MM	NONE	X		X	X	133,414	267,531
INDIANA	LOUISVILLE	CLARK	250M-1MM	(25k	X		X		44,144	88,838
		FLOYD	250M-1MM	(25k	X		X		28,810	61,169
	CHICAGO	LAKE	250M-1MM	(25k	X		X	X	187,612	522,965
		PORTER	250M-1MM	(25k	X		X	X	55,356	119,816
KENTUCKY	CINCINNATI	BOONE	1MM-3MM	NONE	X				25,443	45,842
		CAMPBELL	1MM-3MM	NONE	X				29,817	83,317

Table G-3. NONATTAINMENT AREA DATA
(continued)

STATE	METROPOLITAN AREA	COUNTY	POPULATION RANGE	SERVICE STATION STAGE I EXEMPT.	NONATTAINMENT AREA GROUPS				1980 BASELINE THRUPUT (1000 GAL/YR)	1980 POPULATION
					ALL ([illegible])	SELECTED ([illegible])	27 AREAS	11 AREAS		
		KENTON	1M-3M	NONE	X				47,379	137,058
	LOUISVILLE	JEFFERSON	250K-1M	NONE	X		X		263,606	685,004
LOUISIANA	BATON ROUGE	E. BATON ROUGE	250K-1M	<25K	X		X		152,941	366,191
		W. BATON ROUGE	250K-1M	<25K	X		X		10,492	19,086
	NEW ORLEANS	JEFFERSON	1M-3M	<25K	X				13,871	454,592
		ST. BERNARD	1M-3M	<25K	X				27,756	64,097
		ORLEANS	1M-3M	<25K	X				182,666	557,515
MARYLAND	BALTIMORE	ANNE ARUNDEL	1M-3M	<25K	X	X	X		210,149	370,775
		BALTIMORE	1M-3M	<25K	X	X	X		87,750	655,615
		CARROLL	1M-3M	<25K	X	X	X		30,814	96,356
		HARFORD	1M-3M	<25K	X	X	X		82,935	145,930
		HOWARD	1M-3M	<25K	X	X	X		74,103	118,572
		BALTIMORE CITY	1M-3M	<25K	X	X	X		405,152	786,775
	WASHINGTON	MONTGOMERY	>3M IN SMSA	<25K	X	X	X	X	244,682	579,053
		PRINCE GEORGE'S	>3M IN SMSA	<25K	X	X	X	X	211,957	665,071
		WASHINGTON	<250K IN SMSA	<25K	X		X	X	77,454	113,086
MASSACHUSETTS	STATEWIDE	ALL		NONE	X	X			2,225,059	
		ALL	>3M IN SMSA	NONE	X	X				3,662,832
		ALL	250K-1M	NONE	X	X				1,702,824
		ALL	<250K IN SMSA	NONE	X	X				145,118
		ALL	>25K IN CO.	NONE	X	X				212,248
		ALL	<10K IN CO.	NONE	X	X				14,029
	CENTRAL MASSACHUSETTS APCD	UNKNOWN		NONE			X		393,671	
	WORCESTER-FITCHBURG-LEOMINSTER	WORCESTER	250K-1M	NONE			X			646,352
	PIONEER VALLEY APCD	UNKNOWN		NONE			X		275,336	
	SPRINGFIELD-CHICOPEE-HOLYOKE	HAMPDEN	250K-1M	NONE			X			443,018
		HAMPSHIRE	250K-1M	NONE			X			138,813
	BOSTON METROPOLITAN APCD	UNKNOWN		NONE			X		1,837,100	
	BOSTON-LAWRENCE-LOWELL	ESSEX	>3M IN SMSA	NONE			X			633,632
		MIDDLESEX	>3M IN SMSA	NONE			X			1,367,034
		NORFOLK	>3M IN SMSA	NONE			X			606,587
		PLYMOUTH	>3M IN SMSA	NONE			X			405,437
		SUFFOLK	>3M IN SMSA	NONE			X			650,142
MICHIGAN	DETROIT	MACOMB	>3M IN SMSA	<25K	X		X		235,945	694,600
		OAKLAND	>3M IN SMSA	<25K	X		X		400,170	1,011,793
		WAYNE	>3M IN SMSA	<25K	X		X		892,186	2,3[illegible],891
MISSOURI	ST. LOUIS	FRANKLIN	1M-3M	NONE	X		X	X	45,169	71,233
		JEFFERSON	1M-3M	NONE	X		X	X	66,835	146,183
		ST. CHARLES	1M-3M	NONE	X		X	X	80,647	144,107
		ST. LOUIS	1M-3M	NONE	X		X	X	140,140	973,896
		ST. LOUIS CITY	1M-3M	NONE	X		X	X	475,836	453,085
NEW JERSEY	STATEWIDE	ALL		NONE	X		X	X	3,133,102	
		ALL	>3M IN SMSA	NONE	X		X	X		1,879,494
		ALL	1M-3M	NONE	X		X	X		1,365,569
		ALL	250K-1M	NONE	X		X	X		2,553,591
		ALL	<250K IN SMSA	NONE	X		X	X		326,385
		ALL	>25K IN CO.	NONE	X		X	X		631,704

Table G-3. NONATTAINMENT AREA DATA
(continued)

STATE	METROPOLITAN AREA	COUNTY	POPULATION RANGE	SERVICE STATION STAGE I EXEMPT.	NONATTAINMENT AREA GROUPS: ALL [illegible]	SEL-ECTED [illegible]	27 AREAS	11 AREAS	1982 GASOLINE THRUPUT (1000 GAL/YR)	1980 POPULATION
	NEW YORK	BERGEN	>3MM IN SMSA	NONE					379,349	845,385
		HUDSON	250K-1MM	NONE					152,461	556,972
		MONMOUTH	250K-1MM	NONE					209,687	503,173
		MIDDLESEX	250K-1MM	NONE					247,200	595,893
		ESSEX	1MM-3MM	NONE					275,860	851,116
		MORRIS	1MM-3MM	NONE					185,152	407,630
		SOMERSET	1MM-3MM	NONE					75,995	203,129
		UNION	1MM-3MM	NONE					251,776	504,094
		PASSAIC	250K-1MM	NONE					185,120	447,585
	PHILADELPHIA	BURLINGTON	>3MM IN SMSA	NONE					139,874	362,542
		CAMDEN	>3MM IN SMSA	NONE					108,212	471,650
		GLOUCESTER	>3MM IN SMSA	NONE					94,540	199,917
		MERCER	250K-1MM	NONE					133,761	307,863
NEW YORK	NEW YORK	BRONX	>3MM IN SMSA	<10K	X	X	X	X	144,952	1,168,972
		KINGS	>3MM IN SMSA	<10K	X	X	X	X	276,753	2,230,936
		NEW YORK	>3MM IN SMSA	<10K	X	X	X	X	120,657	1,428,285
		PUTNAM	>3MM IN SMSA	UNC			X	X	47,864	77,193
		QUEENS	>3MM IN SMSA	<10K	X	X	X	X	392,586	1,891,325
		RICHMOND	>3MM IN SMSA	<10K	X	X	X	X	100,191	352,121
		ROCKLAND	>3MM IN SMSA	<10K	X	X	X	X	98,700	259,530
		WESTCHESTER	>3MM IN SMSA	<10K	X	X	X	X	321,343	866,599
		NASSAU	1MM-3MM	<10K	X	X	X	X	540,607	1,321,582
		SUFFOLK	1MM-3MM	<10K	X	X	X	X	402,613	1,284,231
OHIO	AKRON	PORTAGE	250K-1MM	<25K	X				53,346	135,856
		SUMMIT	250K-1MM	<25K	X				209,515	524,472
	CINCINNATI	BUTLER	250K-1MM	<25K	X				94,289	258,787
		CLERMONT	1MM-3MM	<25K	X				53,957	128,483
		HAMILTON	1MM-3MM	<25K	X				345,135	873,224
		WARREN	1MM-3MM	<25K	X				52,430	99,276
	CLEVELAND	CUYAHOGA	1MM-3MM	<25K	X				346,964	1,498,400
		LAKE	1MM-3MM	<25K	X				77,435	212,801
		LORAIN	250K-1MM	<25K	X				91,127	274,909
		MEDINA	1MM-3MM	<25K	X				56,747	113,150
OKLAHOMA	TULSA	TULSA	250K-1MM	UNC	X		X		204,253	470,593
OREGON	PORTLAND	CLACKAMAS	1MM-3MM	<10K	X				87,830	241,919
		MULTNOMAH	1MM-3MM	<10K	X				262,836	562,640
		WASHINGTON	1MM-3MM	<10K	X				88,856	245,808
PENNSYLVANIA	PITTSBURGH	ALLEGHENY	1MM-3MM	NONE	X		X		478,290	1,450,085
		ARMSTRONG	>250K IN CO.	NONE	X		X		47,315	77,768
		BEAVER	1MM-3MM	NONE	X		X		68,393	204,441
		BUTLER	>250K IN CO.	NONE	X		X		76,618	147,912
		WASHINGTON	1MM-3MM	NONE	X		X		114,155	217,074
		WESTMORELAND	1MM-3MM	NONE	X		X		158,346	392,294
	PHILADELPHIA	BUCKS	>3MM IN SMSA	NONE	X	X	X	X	176,612	479,211
		CHESTER	>3MM IN SMSA	NONE	X	X	X	X	163,189	316,660
		DELAWARE	>3MM IN SMSA	NONE	X	X	X	X	191,504	555,007
		MONTGOMERY	>3MM IN SMSA	NONE	X	X	X	X	254,206	643,621

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Table G-3. NONATTAINMENT AREA DATA (concluded)

STATE	METROPOLITAN AREA	COUNTY	POPULATION RANGE	SERVICE STATION STAGE I EXEMPT.	NONATTAINMENT AREA GROUPS				1982 BASELINE THRUPUT (1000 GAL/YR)	1980 POPULATION
					ALL (NA)	SEL-ECTED (NA*)	27 AREAS	11 AREAS		
		PHILADELPHIA	)3MM IN SMSA	NONE	X	X	X	X	397,930	1,688,210
	ALLENTOWN-BETHLEHEM	LEHIGH	250M-1MM	NONE	X		X		93,001	272,349
		NORTHAMPTON	250M-1MM	NONE	X		X		117,612	225,418
	SCRANTON	LACKAWANNA	250M-1MM	NONE	X		X		67,795	227,908
	WILKES BARRE	LUZERNE	250M-1MM	NONE	X		X		110,133	343,079
TEXAS	DALLAS-FORT WORTH	DALLAS	1MM-3MM	(10k	X		X	X	673,196	1,556,390
		DENTON	1MM-3MM	UNC			X		70,423	143,120
		TARRANT	1MM-3MM	(10k	X		X	X	400,377	860,880
	EL PASO	EL PASO	250M-1MM	(10k	X				174,309	479,899
	HOUSTON	HARRIS	1MM-3MM	(10k	X		X	X	1,090,850	2,409,547
UTAH	SALT LAKE CITY	DAVIS	250M-1MM	NONE	X		X		51,890	146,540
		SALT LAKE	250M-1MM	NONE	X		X		214,985	619,066
VIRGINIA	WASHINGTON	ARLINGTON	)3MM IN SMSA	(25k	X	X	X	X	67,934	152,599
		FAIRFAX	)3MM IN SMSA	(25k	X	X	X	X	197,318	596,901
		LOUDOUN	)3MM IN SMSA	UNC	X	X	X	X	35,759	57,427
		PRINCE WILLIAM	)3MM IN SMSA	UNC	X	X	X	X	81,626	144,703
		ALEXANDRIA CITY	)3MM IN SMSA	(25k	X	X	X	X	96,127	103,217
		FAIRFAX CITY	)3MM IN SMSA	(25k	X	X	X	X	15,426	19,390
		FALLS CHURCH CITY	)3MM IN SMSA	(25k	X	X	X	X		9,515
		MANASSAS CITY	)3MM IN SMSA	(25k	X	X	X	X		15,430
		MANASSAS PARK CITY	)3MM IN SMSA	(25k	X	X	X	X		6,524
WASHINGTON	SEATTLE	KING	1MM-3MM	(25k	X				523,007	1,269,749
		PIERCE	250-1MM	(25k	X				176,794	485,643
		SNOHOMISH	1MM-3MM	(25k	X				110,330	337,720
	VANCOUVER	CLARK	1MM-3MM	(25k	X				76,980	192,227
WISCONSIN	MILWAUKEE	KENOSHA	(250M IN SMSA	NONE	X		X		55,552	123,137
		MILWAUKEE	1MM-3MM	NONE	X		X		333,630	964,988
		OZAUKEE	1MM-3MM	NONE	X		X		34,770	66,981
		RACINE	(250M IN SMSA	NONE	X		X		66,407	173,132
		WAUKESHA	1MM-3MM	NONE	X		X		110,637	280,326

1982 THRUPUT & 1980 POPULATION FOR NONATTAINMENT GROUPINGS:	THRUPUT (1000 GAL)	POPULATION (1000)	PERCENT OF U.S. THRUPUT	PERCENT OF U.S. POPULATION
ALL NONATTAINMENT AREAS (NA)	30,632,463	81,006	30%	36%
ALL NONATTAINMENT AREAS (NA) WITHOUT STAGE I CONTROLS	1,272,110	2,503	1.2%	1.1%
SELECTED NONATTAINMENT AREAS (NA*)	10,605,436	32,650	10%	14%
SELECTED NONATTAINMENT AREAS (NA*) WITHOUT STAGE I CONTROLS	117,305	202	0.1%	0.1%
27 NONATTAINMENT AREAS	23,814,550	64,271	23%	28%
27 NONATTAINMENT AREAS WITHOUT STAGE I CONTROLS	1,390,397	2,003	1.4%	1.2%
11 NONATTAINMENT AREAS	15,447,225	42,707	15%	19%
11 NONATTAINMENT AREAS WITHOUT STAGE I CONTROLS	1,115,721	2,109	1.1%	1.0%
TOTAL U.S. FIGURES	102,700,000	226,546	NA	NA

Table G-4. COMPOSITION OF "61-AREA" NONATTAINMENT AREA GROUPING[a]

1. Boston Metropolitan Area
2. Greater Connecticut Metro. Area
3. New York City Metropolitan Area
4. Philadelphia Metropolitan Area
5. Miami Metropolitan Area
6. Cincinnati Metropolitan Area
7. Dayton Metropolitan Area
8. Chicago Metropolitan Area
9. Milwaukee Metropolitan Area

10. Portland, ME
11. Portsmouth-Dover-Rochester, NH-ME
12. Providence, RI
13. Worcester, MA
14. Atlantic City, NJ
15. Vineland-Millville-Bridgeton, NJ
16. Allentown-Bethlehem, PA-NJ
17. Baltimore, MD
18. Erie, PA
19. Harrisburg-Lebanon-Carlisle, PA
20. Lancaster, PA
21. Pittsburgh, PA
22. Reading, PA
23. Richmond-Petersburg, VA
24. Scranton-Wilkes Barre, PA
25. Washington, DC-MD-VA
26. York, PA
27. Atlanta, GA
28. Birmingham, AL
29. Charlotte-Gastonia-Rock Hill, NC-SC
30. Chattanooga, TN-GA
31. Huntington-Ashland, WV-KY-OH
32. Louisville, KY-IN
33. Memphis, TN-AR-MS
34. Nashville, TN
35. Tampa-St. Petersburg-Clearwater, FL
36. Akron, OH
37. Canton, OH
38. Cleveland, OH
39. Detroit, MI
40. Grand Rapids, MI
41. Indianapolis, IN
42. Muskegon, MI
43. Baton Rouge, LA
44. Beaumont-Port Arthur, TX
45. Brazoria, TX
46. Dallas, TX
47. El Paso, TX
48. Fort Worth-Arlington, TX
49. Galveston-Texas City, TX

TABLE G-4. COMPOSITION OF "61-AREA" NONATTAINMENT AREA GROUPING[a] (continued)

50. Houston, TX
51. Lake Charles, LA
52. Longview-Marshall, TX
53. New Orleans, LA
54. San Antonio, TX
55. Tulsa, OK
56. Kansas City, MO-KS
57. St. Louis, MO-IL
58. Denver, CO
59. Boulder-Longmont, CO
60. Salt Lake City-Ogden, UT
61. Phoenix, AZ

State and County Breakdown

	1982 Gasoline Consumption (1,000 gal.)
Alabama	
Jefferson	272,470
St. Clair	23,806
Shelby	37,132
Walker	49,300
Arizona	
Maricopa	680,405
Arkansas	
Crittenden	20,207
Colorado	
Adams	92,264
Arapahoe	91,639
Boulder	94,527
Denver	339,665
Douglas	16,900
Gilpin	1,518
Jefferson	97,171
Connecticut	
Fairfield	319,799
Hartford	309,367
Middlesex	78,164
New Haven	275,649
New London	109,064
Tolland	60,271
Delaware	
New Castle	173,770
District of Columbia	271,629

	1982 Gasoline Consumption (1,000 gal.)
Florida	
Broward	482,935
Dade	646,936
Hillsborough	277,927
Palm Beach	248,311
Pasco	90,034
Pinellas	337,772
Georgia	
Butts	8,238
Catoosa	12,557
Cherokee	29,749
Clayton	64,127
Cobb	171,621
Dade	7,685
De Kalb	133,636
Douglas	33,987
Fayette	22,338
Forsyth	17,348
Fulton	338,216
Gwinnett	96,838
Henry	26,152
Newton	21,328
Paulding	15,209
Rockdale	22,009
Walker	40,327
Walton	18,614

Table G-4. COMPOSITION OF "61-AREA" NONATTAINMENT AREA GROUPING[a] (continued)

	1982 Gasoline Consumption (1,000 gal.)
Illinois	
Clinton	12,493
Cook	1.664,920
Du Page	298,643
Kane	107,441
Lake	158,522
Madison	127,705
McHenry	48,764
Monroe	8,908
St. Clair	133,414
Will	141,713
Indiana	
Boone	20,355
Clark	44,144
Dearborn	17,203
Floyd	28,810
Hamilton	44,463
Hancock	25,549
Hendricks	36,887
Johnson	38,044
Lake	187,612
Marion	302,218
Morgan	29,104
Porter	55,358
Shelby	21,554
Kansas	
Johnson	122,150
Wyandotte	83,221
Kentucky	
Boone	25,403
Boyd	29,487
Bullitt	17,956
Campbell	29,017
Greenup	19,655
Jefferson	265,686
Kenton	47,370
Oldham	13,028
Louisiana	
Ascension	28,690
Calcasieu	74,388
East Baton Rouge	152,941
Jefferson	13,871
Livingston	37,109
Orleans	182,666
St. Bernard	27,766
St. Tammany	69,101
West Baton Rouge	10,492
Maine	
Cumberland	103,520
Sagadahoc	11,460
York	63,975
Maryland	
Anne Arundel	196,401
Baltimore	82,019
Carroll	84,873
Cecil	38,712
Charles	49,285
Harford	77,509
Howard	69,255
Montgomery	228,676
Prince George's	198,091
Massachusetts	
Bristol	1,037,100[b]
Essex	b
Hampden	250,000[c]
Hampshire	c
Middlesex	b
Norfolk	b
Plymouth	b
Suffolk	b
Worcester	303,671
Michigan	
Kent	175,119
Lapeer	38,801
Livingston	52,839
Macomb	295,945
Muskegon	76,327
Oakland	408,170
Oceana	13,800
Ottawa	95,545
St. Clair	76,401
Wayne	892,186
Mississippi	
De Soto	25,323
Missouri	
Cass	31,189
Clay	19,837
Franklin	45,169
Jackson	328,795
Jefferson	86,835
Platte	7,406
Ray	11,273
St. Charles	88,647
St. Louis	148,148
New Hampshire	
Rockingham	99,162
Strafford	24,687

Table G-4. COMPOSITION OF "61-AREA" NONATTAINMENT AREA GROUPING[a] (continued)

	1982 Gasoline Consumption (1,000 gal.)
New Jersey	
Atlantic	70,748
Bergen	379,349
Burlington	139,074
Camden	188,212
Cumberland	66,513
Essex	275,860
Gloucester	94,540
Hudson	152,461
Mercer	133,761
Middlesex	247,280
Monmouth	209,687
Morris	185,152
Passaic	185,128
Salem	32,238
Somerset	76,995
Union	251,776
Warren	47,913
New York	
Bronx	140,952
Kings	276,753
Nassau	548,607
New York	120,657
Putnam	47,864
Queens	382,686
Richmond	100,191
Rockland	98,708
Suffolk	483,613
Westchester	321,343
North Carolina	
Gaston	62,341
Mecklenburg	150,363
Union	30,791
Ohio	
Butler	94,289
Carroll	11,115
Champaign	18,505
Clark	74,593
Clermont	53,967
Cuyahoga	546,964
Geauga	35,135
Greene	52,719
Hamilton	345,136
Lake	77,435
Lawrence	28,834
Medina	56,747
Miami	51,275
Montgomery	236,001
Portage	59,346
Preble	25,447
Stark	204,832
Summit	209,515
Warren	52,438
Oklahoma	
Creek	35,022
Mayes	23,486
Osage	28,402
Rogers	33,568
Tulsa	204,253
Wagoner	30,540
Pennsylvania	
Adams	39,920
Allegheny	478,290
Beaver	68,393
Berks	144,040
Bucks	176,612
Carbon	24,356
Chester	163,189
Cumberland	91,961
Dauphin	88,869
Delaware	191,584
Erie	91,173
Lackawanna	69,795
Lancaster	158,787
Lehigh	93,001
Luzerne	110,133
Monroe	37,837
Montgomery	254,206
Northampton	117,612
Perry	21,629
Philadelphia	397,930
Washington	114,155
Westmoreland	168,346
York	143,944
Rhode Island	
Bristol	11,749
Kent	61,842
Providence	195,687
Washington	59,427
Tennessee	
Cheatham	12,492
Davidson	208,711
Dickson	17,706
Hamilton	121,985
Marion	15,874
Robertson	20,589
Sequatchie	4,482
Shelby	284,425
Tipton	19,234

Table G-4. COMPOSITION OF "61-AREA" NONATTAINMENT AREA GROUPING[a] (continued)

	1982 Gasoline Consumption (1,000 gal.)
Texas	
Bexar	433,163
Brazoria	73,262
Collin	54,089
Comal	26,606
Dallas	673,196
Denton	70,423
Ellis	46,860
El Paso	174,309
Fort Bend	57,864
Galveston	91,866
Gregg	55,781
Guadalupe	33,912
Hardin	22,749
Harris	1,090,858
Harrison	40,667
Hood	9,434
Jefferson	136,290
Johnson	33,856
Kaufman	38,314
Liberty	31,270
Montgomery	70,023
Orange	47,700
Parker	32,488
Rockwall	13,208
Tarrant	408.377
Waller	17,398
Wise	24,257

	1982 Gasoline Consumption (1,000 gal.)
Utah	
Davis	51,890
Salt Lake	214,985
Tooele	20,312
Weber	65,276
Virginia	
Arlington	67,934
Charles City	2,922
Chesterfield	35,106
Fairfax	197,318
Goochland	5,558
Hanover	35,013
Henrico	78,185
Loudoun	35,759
New Kent	6,640
Powhatan	7,696
Prince William	81,626
West Virginia	
Cabell	43,258
Wayne	16,801
Wisconsin	
Kenosha	55,552
Milwaukee	333,638
Ozaukee	34,770
Racine	66,407
Sheboygan	47,723
Washington	47,540
Waukesha	110,637

Also included in the 61-area groupings are five cities not covered in the counties listed above. These are:

Baltimore, MD	453,413	(1,000 gal.)
St. Louis, MO	475,836	"
Alexandria, VA	96,127	"
Fairfax, VA	15,426	"
Richmond, VA	112,668	"

Total 1982 gasoline consumption for the 61 NA areas = 36,213,900 (1,000 gal.).

1982 nationwide consumption = 102,718,987 (1,000 gal.).

61-area percentage of total consumption = 35.3 percent.

Table G-4. COMPOSITION OF "61-AREA" NONATTAINMENT AREA GROUPING[a] (concluded)

Notes

[a] Includes non-California areas only. Metropolitan areas (1 through 9) generally conform to Standard Consolidated Statistical Areas defined by OMB. Other areas (10 through 61) generally conform to Standard Metropolitan Statistical Areas or New England County Metropolitan Areas defined by OMB.

[b] The Boston Metro Area, composed of Bristol, Essex, Middlesex, Norfolk, Plymouth, and Suffolk Counties, had a total consumption of 1,037,100 x 10^3 gallons.

[c] No data were available for these two counties. The total of 250,000 x 10^3 gallons is an estimate.

APPENDIX H

A PRELIMINARY ESTIMATION OF OCCUPATIONAL RISK TO SERVICE STATION ATTENDANTS EXPOSED TO BENZENE AND GASOLINE VAPORS

A Preliminary Estimation of Occupational Risk to Service Station Attendants Exposed to Benzene and Gasoline Vapors

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Introduction

In accordance with a request of the Office of Policy Analysis, OAQPS has estimated the risk of benzene and gasoline vapor exposure to service station attendants. While occupational exposure studies are within the administrative purview of NIOSH and OSHA, this analysis is but a crude estimation of occupational risk and is not intended to usurp the responsibilities of other regulatory agencies. The purpose of the analysis is to give EPA an approximation of lifetime individual risk and annual cancer incidence resulting from long-term exposure to gasoline vapors in the occupational setting.

Methodology

In 1979 the Shell Oil Co. reported the results of an analysis of service station attendants exposed to benzene and gasoline vapors (American Industrial Hygiene Association Journal (40), April, 1979). Seven service stations were evaluated on the following criteria: large sales volume of gasoline; at least some full service sales because self service station exposures to employees were believed to be minimal, and geographical distribution throughout the U.S. One service station was equipped with vapor recovery nozzles on the pumps (a balance system). Sampling was done from March to July, and each location was sampled on six different days. Vapor samples were collected using battery powered personal pumps and reusable stainless steel tubes containing Bendix PMCC, an activated carbon. Long-term samples during the regular work shift were conducted at a pumping rate of 50-75 cc air per minute. Tubes were changed after 4 hours of use. The sampling tubes were attached to the attendant's collar in a position close to his/her breathing zone. Field blanks were used each day for quality control. Sampling pumps were calibrated daily. Benzene and other hydrocarbons comprising the vapor portion of the gasoline that was adsorbed onto the tubes were analyzed using gas chromatography. The term "pumping" gasoline, for purposes of Shell's exposure study, referred to filling cars, checking under the hood, washing car windows, and collecting cash or filling out charge slips. It was noted that some attendants used the hold-open latch on the fill nozzle more frequently than others, and, therefore exposure to gasoline vapors varied widely even among attendants spending a large percentage of their shift pumping gasoline. The location of the sampled stations is shown in Table 1. When possible at least two service station attendants were monitored at each location. A total of 84 time weighted averages (TWA) of attendant's exposure to benzene and gasoline vapors were derived at the 7 service stations. Table 2 summarizes the TWA exposure to benzene vapor, and Table 3 shows the attendant's TWA exposure to total gasoline vapor. The volume percent concentration of benzene in the liquid of regular, unleaded, and premium were 0.47 to 1.17%, 0.42 to 1.74%, and 0.41 to 1.69%, respectively. In the Shell study no correlation was found between the exposure to benzene and the following parameters: auto fill opening location, benzene content of the gasoline, gasoline storage tank temperatures, or the gasoline volatility as measured by Reid Vapor Pressure. The investigators speculated that the factors effecting exposure were vapor dilution caused by the movement of air, and the total time spent near the auto fill opening during pumping.

For purposes of this preliminary occupational risk assessment, the benzene and total gasoline vapor exposures were assumed by averaging the mean TWA concentration measured at 7 service stations. Therefore the estimated exposure was calculated as the arithmetic average for 7 service stations. The Shell report had loosly defined the term pumping gas to include, among other activities, collecting cash and filling out charge slips. By this definition personnel employed at 100% self service stations may be expected to be exposed to similar TWA concentrations as reported in the Shell study. However, no estimates of risk to attendants at 100% self-service sations was made in this report. The purpose of this preliminary risk assessment is to grossly estimate the potential risk in the occupational setting at public service stations.

Exposure Analysis

The TWA's for benzene and gasoline vapor exposure are adjusted to a continuous exposure in ppm using the following assumptions:

(1) There are 6 attendants at each service station in which the labor is divided by 3 attendants each shift for 2 shifts.

(2) The attendants work 8 hours per day, 5 day/week, 50 weeks/year.

(3) The attendants work a total of 50 years in the same occupation.

The TWA is adjusted to a lifetime exposure by:

$$\text{TWA (ppm)} \times \left(\frac{8 \text{ hrs}}{24 \text{ hrs}} \times \frac{5 \text{ days/wk}}{7 \text{ days/wk}} \times \frac{50 \text{ wk/yr}}{52 \text{ wk/yr}} \times \frac{50 \text{ yrs}}{70 \text{ yr lifetime}} \right).$$

The maximum individual lifetime risk is calculated by the exposure times the unit leukemia risk of benzene or the unit cancer risk of gasoline vapors.

The unit risk of benzene is 2.6×10^{-2} $(\text{ppm})^{-1}$

The unit risk of gasoline vapor is 3.1×10^{-3} $(\text{ppm})^{-1}$

The annual incidence of cancer resulting from a work-life exposure to either benzene vapor or gasoline vapor is determined by: the number of full service stations x 6 attendants per station times the maximum individual risk divided by a 70 year lifespan. For purposes of estimating annual cancer incidence from exposure to benzene or gasoline vapor, it is assumed there are 190,000 public gasoline service station outlets in the U.S., and 30% of these outlets are estimated to be 100% full service. Therefore for purposes of this analysis, 57,000 service stations are assumed to be full service.

Results

I. Service Station Attendant Exposure to Benzene Vapor.

Average concentration is estimated to be 0.08 ppm benzene from 8-hour TWA measurements taken at seven service stations geographically distributed.

a. Therefore the individual lifetime cancer risk from benzene exposure is estimated by:

individual lifetime cancer risk =

$$0.08\text{ ppm Bz} \times \left(\frac{8\text{ hrs}}{24\text{ hrs}} \times \frac{5\text{ days/wk}}{7\text{ days/wk}} \times \frac{50\text{ wk/yr}}{52\text{ wk/yr}} \times \frac{50\text{ yrs}}{70\text{ yr lifetime}}\right) \times 2.6\text{x}10^{-2}(\text{ppm})^{-1}$$

individual lifetime cancer risk = 3.4×10^{-4}, or the probability of contracting cancer from a lifetime of exposure to the average Bz concentration of about 3 chances in 10,000.

b. Annual cancer incidence is estimated by the formula:

Annual cancer incidence nationwide = (57,000 full-service stations x 6 attendants per station x $3.4\text{x}10^{-4}$ individual lifetime risk) ÷ 70 years.

Annual cancer incidence = 1.7 cases per year.

II. Service Station Attendance Exposure to Gasoline Vapor.

Average concentration is estimated to be 8.28 ppm gasoline vapor (GV) from 8 hr-TWA measurements taken at seven service stations geographically distributed.

a. The individual lifetime cancer risk from gasoline vapor exposure is estimated by:

individual lifetime risk =

$$8.28\text{ ppm GV} \times \left(\frac{8\text{ hrs}}{24\text{ hrs}} \times \frac{5\text{ days/week}}{7\text{ days/week}} \times \frac{50\text{ wk/yr}}{52\text{ wk/yr}} \times \frac{50\text{ yrs}}{70\text{ yrs}}\right) \times 3.1\text{x}10^{-3}(\text{ppm})^{-1}$$

individual lifetime cancer risk = $4.1\text{x}10^{-3}$ or a probability of about 4 chances in 1000 of contracting cancer from a lifetime exposure to the average concentration of gasoline vapor.

b. Annual cancer incidence is estimated by the formula.

Annual cancer incidence = (57,000 full-service stations x 6 attendants per station x $4.1\text{x}10^{-3}$ individual lifetime risk) ÷ 70 years.

Annual cancer incidence = 20 cases per year.

TABLE 1
Service Station Sampling Locations

Location	Type of Station
Houston, TX	40% Full Service, 60% Self Service, Carwash 2 attendants spend 25-50% of time pumping gas
Manhattan Beach, CA	100% Full Service 2 attendants spend 40-65% of time pumping gas
New Britain, CT	100% Full Service, Carwash 1 attendant spends 50% of time pumping gas
New Orleans, LA	35% Full Service, 65% Self Service, Carwash 2 attendants spend 30-50% of time pumping gas
Plantation, FL	60% Full Service, 40% Self Service 2 attendants spend 70-80% of time pumping gas
Stickney, IL	100% Full Service 2 attendants spend 75-80% of time pumping gas
Walnut Creek, CA	45% Full Service, 55% Self Service (vapor recovery nozzles) 2 attendants spend 50-75% of time pumping gas

TABLE 2
Attendants' TWA Exposures to Benzene Vapor

Location	No. of TWA Exposures	TWA Exposure to Benzene Vapor, ppm		
		Range	Median	Mean
Houston, TX	12	<0.01-0.17	0.01	0.02
Manhattan Beach, CA	10	<0.01-0.18	0.04	0.06
New Britain, CT	19	<0.01-2.08	0.04	0.24
New Orleans, LA	10	<0.01-0.15	0.03	0.04
Plantation, FL	12	<0.01-0.17	0.05	0.06
Stickney, IL	10	<0.01-0.84	0.01	0.11
Walnut Creek, CA	11	<0.01-0.44	0.01	0.05

Average
Concentration: .08

TABLE 3
Attendants' TWA Exposures to Total Gasoline Vapor

Location	No. of TWA Exposures	TWA Exposure to Total Gasoline Vapor, ppm*		
		Range	Median	Mean
Houston, TX	12	0.62- 7.24	2.97	3.63
Manhattan Beach, CA	10	1.65- 14.72	5.99	6.23
New Britain, CT	19	0.46-114.29	5.31	22.30
New Orleans, LA	10	0.73- 10.89	6.02	5.87
Plantation, FL	12	2.33- 20.79	8.89	9.26
Stickney, IL	10	0.81- 40.42	2.42	6.97
Walnut Creek, CA	11	0.42- 14.51	2.30	3.71

* Includes benzene vapor

Average
Concentration: 8.28

APPENDIX I

ANALYSIS OF STAGE II DISPENSER CONFIGURATIONS

APPENDIX I
ANALYSIS OF STAGE II DISPENSER CONFIGURATIONS

I.1 INTRODUCTION

Several comments were received during the public comment period concerning the Stage II costing procedures used in the July 1984 analysis of gasoline marketing facilities. Comments were received on both sides of the issue; some felt that the EPA Stage II cost estimates were too high, while some felt the estimates were too low. In an attempt to present a more detailed, documented cost approach, EPA conducted a component-by-component analysis of Stage II systems (found in Appendix B of this document). A preliminary draft of this analysis (dated July 30, 1986) was released under a Freedom of Information Act request and put into the public docket (I-C-59).

A public comment was received in November 1986 indicating an apparent error in the preliminary draft analysis (I-D-250). Upon review of the calculations, an error was found in the number of nozzles used to calculate annual maintenance costs for existing stations and the analysis was corrected. At the same time, it was determined that two Stage II dispenser hardware scenarios (co-axial hose configurations and multiproduct dispensers) were underestimated in the analysis. Since early 1985 when this detailed Stage II cost estimate was completed, use of the higher cost co-axial hoses and multiproduct dispensers have become the industry trend. Multiproduct dispensers consist of equipment where each grade of gasoline is available on each side of the dispenser (see Figure I-1). Assuming the use of multiproduct dispensers increases the costs because more nozzles are involved than with conventional dispensers. Through observations of new Stage II installations and through discussions with Stage II operators and equipment vendors, it is apparent that most, if not all, new Stage II installations would tend toward co-axial hose configurations and that a significant portion of the existing and new service stations will be using multiproduct dispensers.

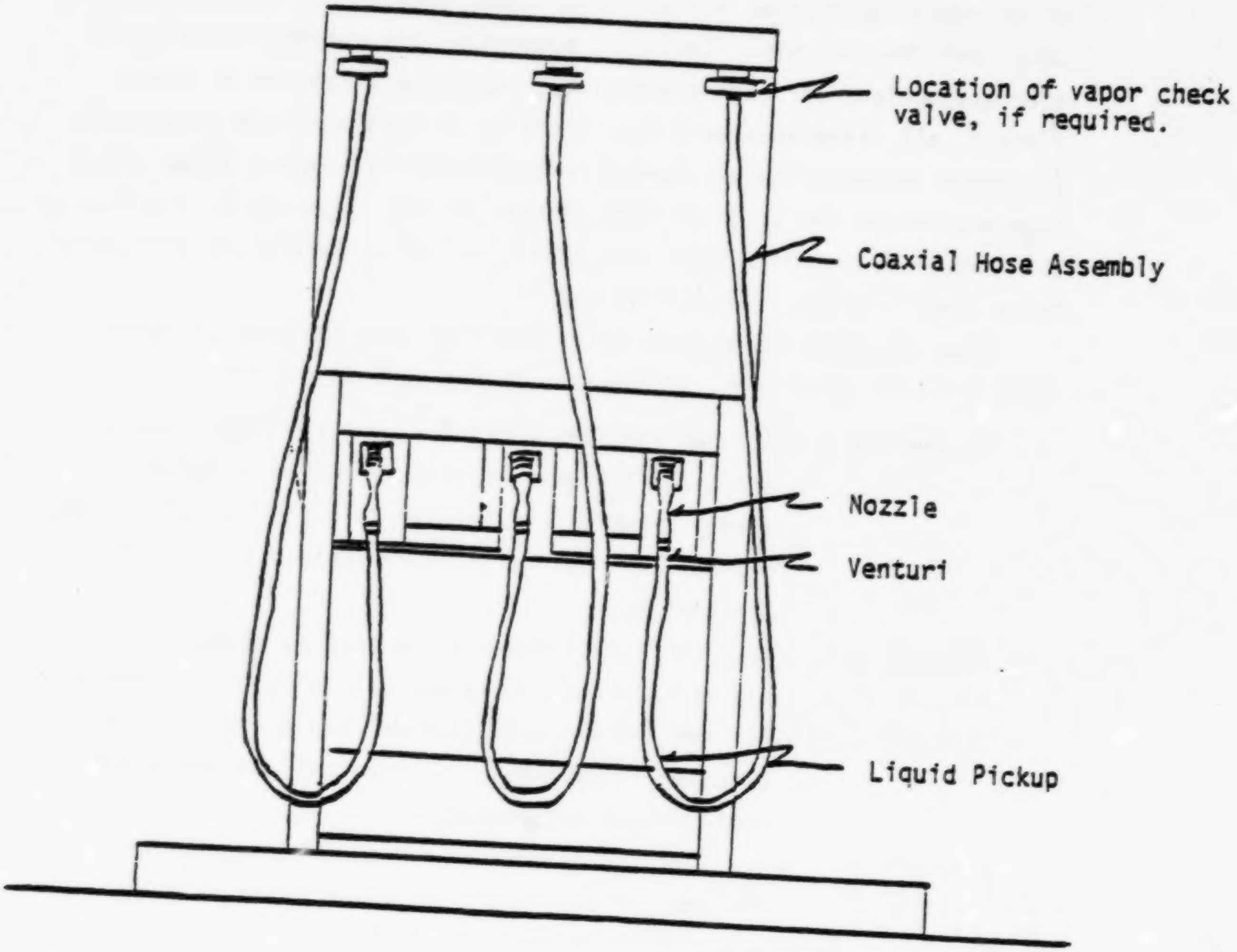
Location of vapor check valve, if required.
Coaxial Hose Assembly
Nozzle
Venturi
Liquid Pickup

Figure I-1. Multiproduct Dispenser

I.2 STAGE II DISPENSER CONFIGURATION ASSUMPTIONS

Several cases were analyzed concerning dispenser configuration to estimate the impact on Stage II costs. The base case, to which the other assumptions were compared, consisted of many of the same assumptions regarding nozzles for different model station sizes used in the July 1984 EPA analysis. Table I-1 summarizes the dispenser configuration assumptions for each model plant. With the exception of Model Plant 5, all dispensers were considered to be single nozzle dispensers. Dispenser hardware was considered to be evenly distributed between twin hose assemblies and co-axial hose assemblies (see Appendix B, Figures B-1 through B-4), since both were certified in California and both were being used in Stage II installations.

Five dispenser configuration assumptions were analyzed as variations from the base case. These assumptions were as follows:

Assumption 1 - All new stations would use co-axial hoses, while existing (retrofit) facilities would be split evenly between co-axial and twin hose configurations. One-half of the new stations would use multiproduct dispensers.

Assumption 2 - Hose configurations are the same as Assumption 1. All new stations would use multiproduct dispensers.

Assumption 3 - All new and existing stations would use co-axial hose configurations. All new stations would use multiproduct dispensers.

Assumption 4 - Hose configurations are the same as Assumption 3. All new and one-fourth of the existing stations would use multiproduct dispensers.

Assumption 5 - Hose configurations are the same as Assumption 3. Three-fourths of the new and one-fourth of the existing stations would use multiproduct dispensers.

For purposes of this analysis it was assumed that each island shown in Table I-1 was replaced with a multiproduct dispenser (a conservative estimate). Two variations of multiproduct dispensers were evaluated. A 6-nozzle multiproduct dispenser would have a nozzle for leaded regular, unleaded regular, and unleaded premium on each side. A 4-nozzle multiproduct would only have unleaded regular and premium on each side. The 4-nozzle multiproduct dispenser represents the scenario of a two-product distribution system after the phase-out of leaded gasoline. Table I-2 summarizes the dispenser configurations considered for multiproduct dispensers.

I.3 RESULTS OF THE ANALYSIS

Table I-3 summarizes the results of the analysis. The base case and corrected base case are calculated in the same manner as in the July 30, 1986 draft analysis (equipment installation start-date of 1989). The calculations for each assumption reflect an equipment installation start date of 1990. Shown in the table are costs for a Stage II nationwide strategy assuming an exemption for all facilities less than 10,000 gallons per month and independent facilities less than 50,000 gallons per month. Costs are presented for both annual and minimal enforcement scenarios. In addition, cost effectiveness, in dollars per megagram of VOC reduced, is presented. As is expected, the costs and cost effectiveness values increase as the assumptions on the use of multiproduct dispensers increase.

I.4 CONCLUSIONS

I.4.1 Hose Configurations

Observations of the newest co-axial hose configuration (I-B-36) indicate that these hoses are extremely light and flexible. These hoses eliminate the visual impact on the consumer of two hoses and eliminate the twisting and kinking problems associated with the twin hose assembly. In addition, California now requires co-axial configurations on all new Stage II installations. Therefore, EPA assumes for this analysis that all new and retrofit systems installed will be co-axial hose configurations.

I.4.2 Dispenser Configurations

Many service stations are currently converting their existing gasoline dispensing equipment to multiproduct dispensers. Vendors of

Table I-2. DISPENSER CONFIGURATIONS ASSUMED FOR MULTIPRODUCT DISPENSERS

4-Nozzle Multiproduct Dispenser

	Model Plant				
	1	2	3	4	5
Number of Islands	1	1	2	3	4
Number of Dispensers	1	1	2	3	5[a]
Number of Nozzles	4	4	8	12	20

6-Nozzle Multiproduct Dispenser

	Model Plant				
	1	2	3	4	5
Number of Islands	1	1	2	3	4
Number of Dispensers	1	1	2	3	5[a]
Number of Nozzles	4[b]	6	12	18	30

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[a] Number of dispensers exceed the number of islands to account for dual dispensers assumed in the base case.

[b] Only four nozzles assumed for consistency with the assumption of only two products available for Model Plant 1.

Table I-3. SUMMARY OF ANALYSIS OF STAGE II DISPENSER CONFIGURATION ASSUMPTIONS

	Nationwide Stage II (Ex. <10, <50)			
	Annualized Cost (w/enforcement), $ Million		Cost Effectiveness, $/Mg	
	Annual	Minimal	Annual	Minimal
BASE CASE				
Original Calculations [July 30, 1986 draft analysis]				
All single dispensers 1/2 coax, 1/2 twin hose Hardware	224	193	861	1,121
Replacement calculations twin hose balance & vacuum assist systems				
CORRECTED CALCULATIONS				
As above, with nozzle correction, hose correction, & recovery credit correction for assist systems	181	160	695	931
Assumption 1a				
All new station coax, 1/2 new stations MPD (4), 1/2 existing stations coax	174	150	741	968
Assumption 1b				
All new station coax, 1/2 new stations MPD (6), 1/2 existing stations coax	195	165	829	1,066
Assumption 2a				
All new station coax, All new stations MPD (4), 1/2 existing stations coax	183	158	778	1,018
Assumption 2b				
All new station coax, All new stations MPD (6), 1/2 existing stations coax	216	189	923	1,215

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Table I-3. SUMMARY OF ANALYSIS OF STAGE II DISPENSER CONFIGURATION ASSUMPTIONS (concluded)

	Nationwide Stage II (Ex. <10, <50)			
	Annualized Cost (w/enforcement), $ Million		Cost Effectiveness, $/Mg	
	Annual	Minimal	Annual	Minimal
Assumption 3a				
All new stations MPD (4) All existing & new stations coax	188	163	803	1,051
Assumption 3b				
All new stations MPD (6) All existing & new stations coax	222	194	947	1,248
Assumption 4a				
All new stations MPD (4) All existing & new stations coax 1/4 existing stations MPD (4)	195	168	829	1,088
Assumption 4b				
All new stations MPD (6) All existing & new stations coax 1/4 existing stations MPD (6)	244	213	1,040	1,375
Assumption 5a				
3/4 new stations MPD (4) All existing and new stations coax 1/4 existing stations MPD (4)	190	165	811	1,063
Assumption 5b				
3/4 new stations MPD (6) All existing and new stations coax 1/4 existing stations MPD (6)	231	202	985	1,330

multiproduct dispensers indicate that these dispensers make up 25 to 50 percent of the current dispenser market (I-E-62, 65, 66). Vendors also indicate a higher percentage (60-90 percent of the market) for new facilities (I-E-66). The EPA believes, therefore, that by the time a Stage II regulation is implemented, a significant portion of the existing dispensers would have already converted to multiproduct dispensers and an even higher percentage of brand new facilities will incorporate this technology. Thus, Assumption 5 (25% existing, 75% new stations with multiproduct dispensers) represents a reasonable (if not understated) representation of future gasoline marketing dispenser procurement.

Further, EPA believes that the ban on leaded gasoline will be complete by the late 1980's. Since there is little information available on the development of a mid-grade unleaded and since in the EPA analysis Stage II essentially begins after the projected ban on leaded gasoline, a two-product, 4-nozzle multiproduct dispenser configuration appears to be best suited for use in the Stage II analysis.

I.5 REFERENCES

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APPENDIX J

STAGE I PER-FACILITY COSTS

APPENDIX J

STAGE I PER-FACILITY COSTS

In EPA's new analysis, per-facility control cost estimates have been developed for each source category within the gasoline marketing network. This appendix presents cost tables for bulk terminals (Tables J-1 through J-4), storage tanks (Table J-5), bulk plants (Tables J-6 and J-7), tank trucks (Tables J-8 and J-9), and Stage I control at service stations (Table J-10). The costs of service station Stage II control are examined in detail in Appendix B of this document.

The tables in this appendix are updated versions of several of the tables in Chapter 7 of EPA's July 1984 analysis document (I-A-55). In that analysis, the costs were estimated in terms of 4th quarter 1982 dollars. The new baseline for the tables presented in this appendix is 3rd quarter 1984 dollars, in order to be consistent with the Stage II cost data collected in the new analysis. In general, the 1982 costs have been increased by multiplying them by a factor of 1.024, as indicated by the plant cost indices of 323.6 (August 1984) and 316.1 (December 1982) in the CE Economic Indicators (I-F-79, I-F-112).

In addition to the general cost increase using cost indices, some assumptions have been revised which affect certain cost parameters in these tables. In general, the recovery credits for all per-facility costs were changed due to changes in the cost of gasoline used in the recovery credits and in the RVP used in the emission reduction calculation. These revisions are discussed in detail in Section 2.5.2 of Chapter 2.

J.1 NEW ASSUMPTIONS AFFECTING PER-FACILITY COSTS

The average purchase cost estimate for carbon adsorption type vapor processors at bulk terminals was reduced based on more current capital costs for the units of one manufacturer (I-H-27). This cost revision represents a 20 percent decrease for this vendor's equipment, and an approximate 8 percent decrease in the average cost of a carbon adsorption system.

In the new analysis, an error was corrected in the calculation of product recovery credits for bulk plants resulting from vapor balance controls. This change corrected an omission in the 1984 analysis, in which the recovery credit associated with tank emptying losses was not considered, by now adding this recovery credit and lowering the net annual control cost and cost effectiveness for bulk plant controls.

Table J-1. BULK TERMINAL BOTTOM LOAD CONTROL COSTS*
(Thousands of 3rd Quarter 1984 Dollars)

Gasoline Throughput	380,000 l/day			950,000 l/day			1,900,000 l/day			3,800,000 l/day		
Vapor Processor	CA[a]	TO[b]	REF[c]	CA	TO	REF	CA	TO	REF	CA	TO	REF
Capital Investment												
Unit purchase cost	125	118	146	152	129	150	160	129	150	209	133	191
Unit installation cost	106	100	124	129	110	128	136	110	128	178	113	163
Truck vapor recovery cost[d]	10	10	10	20	20	20	29	29	29	65	65	65
Annual Operating Costs												
Electricity[g]	6.8	3.1	19.6	10.0	7.9	22.1	15.5	14.6	22.1	29.0	27.9	29.3
Propane (pilot)[h]	--	3.1	--	--	5.5	--	--	10.1	--	--	13.3	--
Carbon replacement[i]	1.2	--	--	1.8	--	--	1.8	--	--	2.1	--	--
Maintenance[j]	5.6	5.3	6.5	6.7	5.8	6.6	7.0	5.8	6.6	9.0	5.9	8.3
Operating labor[k]	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
Truck Testing[l]	1.4	1.4	1.4	2.8	2.8	2.8	4.2	4.2	4.2	9.4	9.4	9.4
Subtotal (direct operating cost)	20.6	18.5	33.1	27.0	27.6	37.2	34.2	40.4	38.6	55.1	62.3	52.6
Capital charges[m] (16.3%)	39.2	37.0	45.7	48.8	42.0	48.5	52.9	43.6	50.1	73.5	50.7	68.2
Taxes, Ins. (4%)	9.5	9.1	11.2	12.0	10.3	11.9	13.0	10.7	12.3	18.1	12.5	16.8
Gasoline recovery[n]	28.3	--	28.3	70.8	--	70.8	141	--	141	283	--	283
Net Annualized Cost	41.2	64.6	61.6	17.0	80.0	26.8	-41.5	94.7	-40.5	-136	125	-145
Total VOC Controlled (Mg/yr)[o]	88.6	88.6	88.6	221	221	221	443	443	443	886	886	886
Cost Effectiveness ($/Mg)	464	729	696	77	361	121	--[p]	214	--[p]	--[p]	141	--[p]

*Source: Updated from bulk terminal NSPS cost estimates (I-A-44) using the CE Plant Cost Index (I-F-79, I-F-112).

Table J-2. BULK TERMINAL TOP LOAD CONTROL COSTS*
(Thousands of 3rd Quarter 1984 Dollars)

Gasoline Throughput	380,000 l/day			950,000 l/day			1,900,000 l/day			3,800,000 l/day		
Vapor Processor	CA[a]	TO[b]	REF[c]	CA	TO	REF	CA	TO	REF	CA	TO	REF
Capital Investment												
Unit purchase cost	125	118	146	152	129	150	160	129	150	209	133	191
Unit installation cost	106	100	124	129	110	128	136	110	128	178	113	163
Rack conversion cost[e]	436	436	436	654	654	654	654	654	654	872	872	872
Truck conversion cost[f]	21	21	21	42	42	42	63	63	63	139	139	139
Annual Operating Costs												
Electricity[g]	6.8	3.1	19.6	10.0	7.9	22.1	15.5	14.6	22.1	29.0	27.9	29.3
Propane (pilot)[h]	--	3.1	--	--	5.5	--	--	10.1	--	--	13.3	--
Carbon replacement[i]	1.2	--	--	1.8	--	--	1.8	--	--	2.1	--	--
Maintenance[j]	5.6	5.3	6.5	6.7	5.8	6.6	7.0	5.8	6.6	9.0	5.9	8.3
Operating labor[k]	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
Truck Testing[l]	1.4	1.4	1.4	2.8	2.8	2.8	4.2	4.2	4.2	9.4	9.4	9.4
Subtotal (direct operating cost)	20.6	18.5	33.1	27.0	27.6	37.2	34.2	40.4	38.6	55.1	62.3	52.6
Capital charges[m] (16.3%)	112	109.8	118	159	152	159	165	155	162	227	205	222
Taxes, Ins. (4%)	27.5	27.0	29.1	39.0	37.4	39.0	40.5	38.2	39.8	55.9	50.3	54.6
Gasoline recovery (credit)[n]	33.0	--	33.0	82.5	--	82.5	165	--	165	330	--	330
Net Annualized Cost	127	155	148	142	217	152	74.4	234	75.4	8.6	317	-0.5
Total VOC Controlled (Mg/yr)[o]	103	103	103	258	258	258	516	516	516	1,033	1,033	1,033
Cost Effectiveness ($/Mg)	1,231	1,504	1,429	552	841	590	144	453	146	8	307	--[p]

*Source: Updated from bulk terminal NSPS cost estimates (I-A-44) using the CE Plant Cost Index (I-F-79, I-F-112).

Notes for Tables J-1 and J-2

[a] Carbon Adsorption Unit.

[b] Thermal Oxidation Unit

[c] Refrigeration Unit.

[d] Cost of installing vapor collection equipment on existing bottom loading tank trucks, $3,255 per truck.

[e] Cost of converting top loading racks to bottom loading and vapor recovery, $205,000 per rack.

[f] Cost of retrofitting existing top loading tank trucks with bottom loading and vapor collection equipment, $6,945 per truck.

[g] Electricity costs are based on average consumption rates reported by manufacturers.

[h] Propane for pilot burner estimated at 12.5 liters per hour, at $0.19 per liter.

[i] Estimated activated carbon replacement period is 10 years, at $3.85 per kilogram carbon cost.

[j] Estimated as 4 percent of unit purchase cost, plus annual rack vapor collection maintenance of $200 per rack and $200 per terminal.

[k] Daily system inspections at one hour per day, plus a monthly inspection for liquid and vapor leaks in the vapor collection and processing systems.

[l] Cost to perform annual vapor tightness testing, including one-half day downtime, $461 per truck.

[m] Total capital investment x (capital recovery factor + 0.04), where interest rate = 10 percent, equipment economic life = 10 years (0.163 capital recovery factor).

[n] Amount recovered per year, at $0.21 per liter assuming a density of 0.67 kg/liter.

[o] Difference between uncontrolled and controlled emission level.

[p] Cost effectiveness not calculated because net annualized cost is a negative quantity (cost credit).

Table J-3. AVERAGE BULK TERMINAL CONTROL COSTS[a,b]
(Thousands of 3rd Quarter 1984 Dollars)

	Bottom Load				Top Load			
Throughputs (000 l/day)	380	950	1,900	3,800	380	950	1,900	3,800
Capital Investment								
Unit purchase cost	130	144	155	200	130	144	155	200
Unit installation cost	110	122	132	171	110	122	132	171
Rack conversion cost					436	654	654	872
Truck conversion cost					21.0	42	63	139
Truck vapor recovery	10.0	20.0	29.0	65.0				
Total Capital Costs	250	286	316	436	697	962	1,004	1,382
Net Annualized Costs	55.8	41.3	-41.0	-140	143	170	74.9	4.0
Total VOC Controlled (Mg/yr)	88.6	221	443	886	103	258	516	1,033
Cost Effectiveness ($/Mg)	630	186	---[c]	---[c]	1,388	661	145	4

[a] Averaged from cost values in Tables J-1 and J-2.

[b] Costs represent average of all processing units for 380 and 950 throughputs using bottom load and top load. All other costs represent average of CA and REF processing units only (exclude TO costs).

[c] Cost effectiveness not calculated because net annualized cost is a negative quantity (cost credit).

TABLE J-4. BULK TERMINAL AVERAGE WEIGHTED COSTS (THOUSANDS OF THIRD QUARTER 1984 DOLLARS)

Model Plant Size (10^3 liters/day)	% of Facilities Each MP Category	Net Annualized Costs[a]		Capital Costs[a]		Recovery Credit[a]	
		Bottom Load	Top Load	Bottom Load	Top Load	Bottom Load	Top Load
380	48	55.8	143	249	696	18.9	22.0
950	27	41.2	170	285	961	47.1	54.9
1,900	21	-41.0	74.9	316	1,004	142	165
3,800	4	-141	4.1	435	1,381	283	330
Average value (weighted by MP)		23.7	130	281	860	62.8	73.2
Total[b]		87.9		628		69.1	

[a] Average costs per model plant taken from Tables J-1 through J-3.

[b] Obtained by multiplying the average values weighted according to model plant by the 60% of terminals assumed to practice bottom loading and 40% assumed to be in the top load configuration.

Table J-5. COST OF INSTALLING A BOLTED INTERNAL FLOATING ROOF ON AN EXISTING FIXED-ROOF TANK[a,b] (Third Quarter 1984 Dollars)

Capital Cost & Installation		
Degassing[c]		$ 7,515
Basic Roof Cost[d]		$17,188
Liquid-Mounted Primary Seal[e]		$ 4,699
Controlled Deck Fittings		$ 250
5% Retrofit Adder[f]		$ 859
	Total Capital Cost	$30,511
Annualized Cost		
Maintenance (5%)		$1,526
Taxes, Insurance, G&A (4%)		$1,220
Inspections (1%)		$ 305
Capital Charges[g]		$3,584
	Total Annualized Cost	$6,635
	Product Recovery Credit[h]	$18,006
Net Annualized Cost (Savings)		($11,371)

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[a] Tank parameters for fixed roof tank:
Volume = 16,750 bbl = 2,680 m^3
Diameter = 50 ft = 15.2 m
Height = 48 ft = 14.6 m

[b] References (I-A-43, I-A-45).

[c] For an existing tank, the first step is to clean and degass the storage vessel before installation of the floating-roof. Cost for this procedure is based on the following relationship:

$$\text{Total Cleaning Costs} = 130.8 \text{ (tank capacity} = 2{,}680)^{0.5132}$$

[d] Estimated from the equation: Cost ($) = 1,069 D + 939 where D = tank diameter in meters. References (I-A-43, I-A-45).

[e] The cost of the liquid-mounted primary seal is estimated to be $98.40 per linear meter of circumference.

[f] Retrofit costs (installing an internal floating roof in an existing fixed-roof tank) are the cost of additional work (i.e., cutting roof vents) and is estimated as 5 percent of the installed capital cost of new construction.

[g] Capital recovery factor of 0.1176 is based on a 10 percent interest rate and 20 year lifetime for the tank and floating roof.

[h] Amount recovered per year, at $0.21 per liter assuming a density of 0.67 kg/liter. Based on emission factors between controlled [internal floating-roof losses if $(7.3285 \times 10^{-8}Q) + 2.4$ Mg/yr, where Q is the weighted throughput for all model plants] and uncontrolled (fixed-roof breathing loss of 8.8 Mg/yr and working loss of 34.2 Mg/yr).

Table J-6. AVERAGE CONTROL COSTS FOR BULK PLANTS
(NO EXEMPTIONS)
(3rd Quarter 1984 Dollars)

Model Plant No.	1	2	3	4
Throughput (liters/day)	11,400	24,600	47,300	64,400
Weighted Average Top & Bottom Loading Costs				
Balance Incoming & Outgoing Loads on Uncontrolled Plants[a]				
Capital Cost[b,c]	29,223	29,223	29,223	29,223
Annual O & M (3%)	877	877	877	877
Capital Charge (13.1%)	3,842	3,842	3,842	3,842
Taxes, Ins. (4%)	1,169	1,169	1,169	1,169
Recovery Credit[d]	1,905	4,111	7,904	10,761
Net Annualized	3,983	1,777	-2,016	-4,874
Emission Reduction (Mg/yr)	9.4	20.2	38.9	52.9
Cost Effectiveness ($/Mg)	425	88	--[e]	--[e]
Balance Outgoing Loads on Plants with Incoming Load Balanced[a]				
Capital Cost[b,c]	21,750	21,750	21,750	21,750
Annual O & M (3%)	653	653	653	653
Capital Charge (13.1%)	2,860	2,860	2,860	2,860
Taxes Ins. (4%)	870	870	870	870
Recovery Credit[d]	1,905	4,111	7,904	10,761
Net Annualized	2,477	271	-3,522	-6,379
Emission Reduction (Mg/yr)	5.6	12.0	23.0	31.4
Cost Effectiveness ($/Mg)	446	23	--[e]	--[e]

[a] Includes the cost of retrofitting two account trucks for use in vapor balance service.

[b] Top Load Cost - $19,952 (91%), Bottom Load Cost - $39,895 (9%), Incoming Load Cost - $7,473.

[c] References (I-A-9, I-A-14, I-A-28).

[d] Recovery credits are based on a control efficiency of 90 percent on outgoing loads from a balance system (or storage tank emptying losses), and a product cost of $0.23 per liter.

[e] Cost effectiveness not calculated because net annualized cost is a negative quantity (cost credit).

Table J-7. ESTIMATED CONTROL COSTS FOR BULK PLANTS (EXEMPT 4,000 gal/day) (3rd Quarter 1984 Dollars)

Model Plant No.	1	2	3	4
Weighted Average Top and Bottom Loading Costs				
Throughput (liters/day)	11,400	24,600	47,300	64,400
Balance Incoming Loads and Install Outgoing Submerged Fill on Uncontrolled Plants with < 4,000 gal/day[a]				
Capital Cost[b,c]	8,702	29,223	29,223	29,223
Annual O & M (3%)	261	877	877	877
Capital Charge (13.1%)	1,144	3,842	3,842	3,842
Taxes Ins. (4%)	348	1,169	1,169	1,169
Recovery Credit	1,332[d]	4,111[e]	7,904[e]	10,761[e]
Net Annualized	421	1,777	-2,016	-4,874
Emission Reduction (Mg/yr)	7.7	20.2	38.9	52.9
Cost Effectiveness ($/Mg)	55	88	--[f]	--[f]
To Install Outgoing Submerged Fill on Plants with Incoming Load Balanced < 4,000 gal/day[a]				
Capital Cost[b,c]	1,228	21,750	21,750	21,750
Annual O & M (3%)	37	653	653	653
Capital Charge (13.1%)	162	2,860	2,860	2,860
Taxes Ins. (4%)	49	870	870	870
Recovery Credit	1,332[d]	4,111[e]	7,904[e]	10,761[e]
Net Annualized	-1,084	271	-3,522	-6,379
Emission Reduction (Mg/yr)	3.9	12.0	23.0	31.4
Cost Effectiveness ($/Mg)	--[f]	23	--[f]	--[f]

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[a] Includes the cost of retrofitting two account trucks for use in vapor balance service.

[b] Top Load Costs (91%) - $19,952. Bottom Load Costs (9%) - $39,895, Incoming Load Cost - $7,473.

[c] References (I-A-9, I-A-14, I-A-28).

[d] Recovery credit is based on control efficiency of 58 percent for conversion from top splash loading to submerged fill.

[e] Recovery credits are based on a control efficiency of 90 percent on outgoing loads from a balance system (or storage tank emptying losses), and a product recovery value of $0.23 per liter.

[f] Cost effectiveness not calculated because net annualized cost is a negative quantity (cost credit).

Table J-8. CONTROL COSTS FOR FOR-HIRE TANK TRUCKS AT TERMINALS[a]
(3rd Quarter 1984 Dollars)

No. of Affected Trucks	580	5,220
Bottom Loading & Vapor Recovery		
Capital Investment per Truck	6,945	
Total Capital Costs	4,028,078	
Capital Charges (13.1%)	529,587	
Annual Maintenance/Testing (@ $1,484 per truck)	860,954	
Product Recovery Credit	NA	
Net Annualized Cost	1,390,541	
Vapor Recovery Only		
Capital Investment per Truck		3,255
Total Capital Costs		16,993,453
Capital Charges (13.1%)		2,234,193
Annual Maintenance/Testing (@ $1,484 per truck)		7,748,587
Product Recovery Credit		NA
Net Annualized Cost		9,982,781

TOTAL CAPITAL COST FOR 5,800 FOR-HIRE TANK TRUCKS AT TERMINALS = $21.0 million.

TOTAL ANNUALIZED COST FOR 5,800 FOR-HIRE TANK TRUCKS AT TERMINALS = $11.4 million.

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[a] Reference (I-A-28), updated by the CE Plant Cost Index, shows that bottom loading conversions average about $3,690 per tank truck and that addition of vapor recovery is about $3,255 per tank truck. Also, maintenance costs average $1,023 per year and tank truck testing averages $461 per year.

Table J-9. CONTROL COSTS FOR FOR-HIRE TANK TRUCKS AT BULK PLANTS
(3rd Quarter 1984 Dollars)

NO EXEMPTIONS	
No. of Affected Trucks	16,300
Weighted Average Costs - Top or Bottom Loading and Vapor Recovery	
Capital Investment per Truck[a]	3,590
Total Capital Cost	58,517,000 or $58.5 million
Capital Charges (13.1%)	7,693,451
Annual Maintenance/Testing @ $1,484 per truck)	24,195,780
Total Annualized Cost	31,889,231 or $31.9 million
EXEMPT BULK PLANTS < 4,000 gal/day	
No. of Affected Trucks	9,400
Weighted Average Costs - Top or Bottom Loading and Vapor Recovery	
Capital Investment per Truck[a]	3,590
Total Capital Cost	33,746,000 or $33.7 million
Capital Charges (13.1%)	4,436,714
Annual Maintenance/Testing (@ $1,484 per truck)	13,953,394
Total Annualized Cost	18,390,109 or $18.4 million

[a] Top Load Costs (91%) - $3,255, Bottom Load Costs (9%) - $6,945.

Table J-10. SERVICE STATION STAGE I CAPITAL AND NET ANNUALIZED COST ESTIMATES[a] (3rd Quarter 1984 Dollars)

Capital Cost and Installation	1,738
Annualized Costs	
Maintenance (3%)	52.1
Taxes, Insurance and G&A (4%)	69.5
Capital Charges[b] (0.131)	228
Annualized Cost	350
Recovery Credit	NA
Net Annualized Cost	350
$/Mg, Cost Effectiveness[c]	
MP1 (18,950 liters/mo.)	1,400
MP2 (75,800 liters/mo.)	354
MP3 (132,650 liters/mo.)	202
MP4 (246,350 liters/mo.)	109
MP5 (701,150 liters/mo.)	38.2

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[a] References (I-A-9, I-A-44).

[b] Capital charges are based on a 10 percent interest rate and on equipment life of 15 years.

[c] Since the number of underground storage tanks at service stations do not vary considerably with throughput (storage capacity would vary more), costs to comply with Stage I at affected facilities were assumed to be independent of facility size.

Sample emission reduction calculation:

$$\frac{(1{,}130 - 40)\text{ mg}}{\text{liter}} \times \frac{246{,}350\text{ liters}}{\text{mo.}} \times \frac{12\text{ mo.}}{\text{yr}} \times \frac{\text{Mg}}{10^9\text{ Mg}} = 3.22\text{ Mg/yr.}$$

J.2 REFERENCES

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APPENDIX K

ANALYSIS OF THE IMPACTS OF THE UNDERGROUND STORAGE TANK (UST) PROGRAM ON STAGE II COSTS

APPENDIX K

Analysis of the Impacts of the Underground Storage Tank (UST) Program On Stage II Costs

K.1 INTRODUCTION

The purpose of this Appendix is to analyze the cost impacts of a simultaneous implementation of the EPA Underground Storage Tank (UST) program and a Stage II program. The following items are analyzed and will be discussed in detail in this Appendix:

- Estimate of leaking tank systems and assumed corrective action taken by tank owners;
- Analysis of a 5-year Stage II phase-in rate to coincide with UST implementation;
- Effect on service station costs when considering a simultaneous Stage II/UST program;
- Effect on emission projections caused by new phase-in rates;
- Impact on cost effectiveness calculations.

Coordination with an UST phase-in schedule would tend to slow deployment of a Stage II program, compared to an "optimum" Stage II deployment not linked to UST. The longer Stage II implementation takes, the more it approaches the implementation of an onboard option, thus reducing a potential advantage of Stage II. In this analysis, a five-year phase-in period is assumed, keyed to the UST provisions requiring that all UST systems must comply with release detection requirements within 5 years. It also is assumed that release detection and immediate corrective action at service stations occur at a relatively linear rate over this 5-year period, such that an availability problem does not arise with regard to qualified contractors. This may be an unrealistic assumption. For example, it is likely that tank owners will wait until the last moment to determine if tanks are leaking, in which case there would be a high demand for contractor support, leading to a delay in corrective action and a stretch-out of Stage II implementation. Moreover, to be very conservative, this analysis assumes that about 35 percent of the nation's tanks are leaking, even though more recent information suggests that a more realistic value is about 10%. It is further assumed that this percentage is uniformly distributed, i.e., that any given urban area will have leaks in 35 percent of its gasoline tank population. Obviously, the actual percentage of leaking systems may vary substantially from area to area, as well as the potential savings to be derived from a combined implementation program.

K.2 IMPACTS OF STAGE II/UST PROGRAM ON STAGE II PER-FACILITY COSTS

Per-facility costs are affected by a simultaneous Stage II/UST program by considering the cost savings of installing Stage II at the time underground tanks are being repaired or replaced. The potential cost savings are realized in reduced trenching and paving costs that would have been attributed to the Stage II installation in the absence of any UST activity. This section presents the changes to the per-facility cost model (discussed in detail in Appendix B) when incorporating these potential cost savings.

The key items for determining the impacts of a simultaneous Stage II/UST program on per-facility costs is to determine how many tank system leaks will occur and what equipment will be excavated during repairs or replacement. Due to the lack of data, the number and type of equipment repairs at service stations required under an UST program calls for several assumptions. In discussions with members of EPA's UST program office, the following estimates were made:

(1) A past survey has shown that about 35 percent of all tank systems (i.e., an individual tank and it's piping) were not tight due to the tanks or piping, or both. Some more recent, but limited, information suggests a lower value. UST models predict about 10 percent of all tank systems leak.

(2) Data on types of equipment leaking is very scattered. A reasonable estimate is that 50% of stations with leaks have only piping leaks and the others have either all or one tank

leaking. Twenty-five percent that have tank leaks also have piping leaks.

(3) Of stations with a leaking tank, a best estimate is that 50% have all tanks leaking and the others have only one tank leaking.

(4) Table K-1 estimates the likelihood of various actions being taken if a leaking tank is found.

(5) For piping leaks, it is estimated that 25% excavate all the piping and the rest either dig up the piping at the end of the tank (90%), or dig up the piping at the end of the tank plus the piping under the dispensers (10%).

(6) Although some States and localities have recently set UST regulations, it is assumed for this analysis that little implementation already has taken place (leaks still estimated as discussed in item 1) and that leaking tank systems are distributed evenly across the nation, ownership and size categories.

The assumptions above and the data presented in Table K-1 can be simplified by the use of a flow-diagram decision tree shown in Figure K-1. Percentages shown in parentheses in the figure represent the resultant percentages of all tank systems for each remedy. Table K-2 further summarizes the possible actions taken in response to finding a leak in either the underground piping or underground tank. For each remedy action, the percent of all tank systems assumed to use that remedy is listed. A description is added that summarizes the resulting savings in Stage II trenching associated with each remedy. As can be seen in Table K-2, several repair actions result in the same savings in Stage II trenching. By recombining Table K-2 into like Stage II installation savings categories, a summary of the Stage II per facility cost savings scenarios can be developed. For example, both Actions 1 and 4 (dig up all piping, and dig up all piping and tanks) result in the savings of all trenching costs. Combining these results in 16.9 percent of all systems realizing a savings in all trenching costs. As shown in Table K-3, almost half of the leaking tank system remedies could result in savings of all costs associated with Stage II trenching and repaving.

Table K-4 summarizes for each model plant and for each scenario the length of trench assumed saved and the percentage of total trench

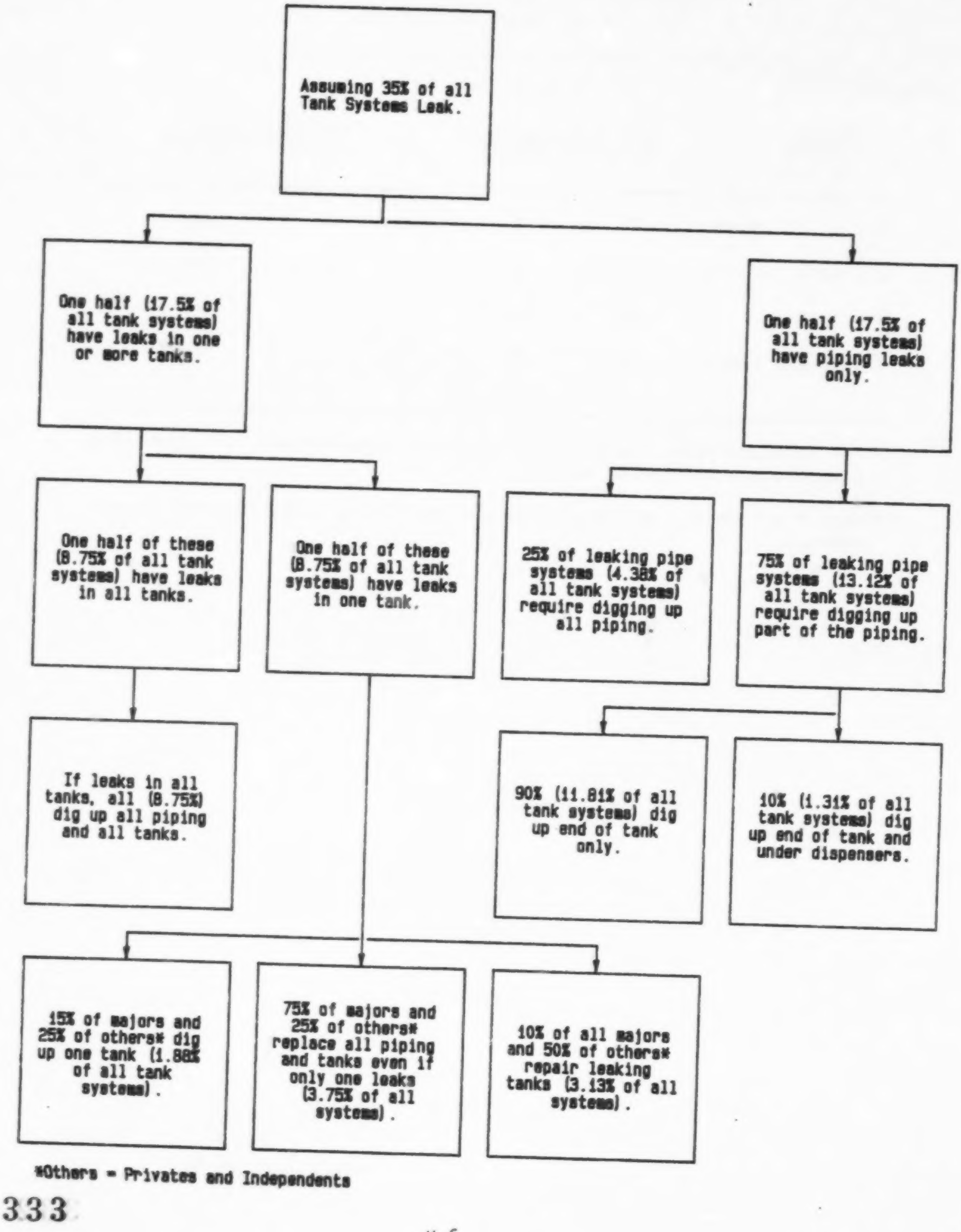
TABLE K-1. ESTIMATES OF ACTIONS TAKEN IF ANY TANKS ARE LEAKING

Action	% Occurrence if: One Tank Leaking		All Tanks Leaking	
	Major*	Other*	Major*	Other*
Dig up all tanks:	75	25	100	100
Dig up all piping:	75	25	100	100
Repair**	10	50	-	-
Dig up one tank:	15	25	-	-

*For this analysis, "other" = privates and independents, all remaining stations are considered majors.

**Repair a tank by just digging up the end of the tank, in order to cut manhole.

Figure K-1. Decision Tree for Tank System Leak Remedies


Assuming 35% of all Tank Systems Leak.
One half (17.5% of all tank systems) have leaks in one or more tanks.
One half (17.5% of all tank systems) have piping leaks only.
One half of these (8.75% of all tank systems) have leaks in all tanks.
One half of these (8.75% of all tank systems) have leaks in one tank.
25% of leaking pipe systems (4.38% of all tank systems) require digging up all piping.
75% of leaking pipe systems (13.12% of all tank systems) require digging up part of the piping.
If leaks in all tanks, all (8.75%) dig up all piping and all tanks.
90% (11.81% of all tank systems) dig up end of tank only.
10% (1.31% of all tank systems) dig up end of tank and under dispensers.
15% of majors and 25% of others* dig up one tank (1.88% of all tank systems).
75% of majors and 25% of others* replace all piping and tanks even if only one leaks (3.75% of all systems).
10% of all majors and 50% of others* repair leaking tanks (3.13% of all systems).

*Others = Privates and Independents

TABLE K-2. ACTIONS TAKEN IN RESPONSE TO FINDING A LEAK IN AN UNDERGROUND TANK SYSTEM[a]

Action	Percent of all Systems	Description of Savings in Stage II Piping Installation
1. Dig up all piping	4.4%	All trenching costs
2. Dig up end of tanks only	11.8%	Trenching costs over end of all tanks
3. Dig up end of tanks and under dispensers	1.3%	Trenching costs over all tanks and under all dispensers
4. Dig up all piping and tanks	12.5%	All trenching costs
5. Dig up only one tank	1.9%	Trenching costs over one tank
6. Repair one leaking tank	3.1%	Trenching costs over one tank
	35%	

[a] See also Figure K-1.

TABLE K-3. SCENARIOS FOR ESTIMATING STAGE II TRENCHING COST SAVINGS

Description of Stage II Piping Installation Savings Scenario	Percent of Leaking Tank Systems	Percent of All Tank Systems
1. All trenching costs	48.3	16.9
2. Trenching costs over ends of all tanks	33.7	11.8
3. Trenching costs over end of all tanks and under all dispensers	3.7	1.3
4. Trenching costs over one tank	14.3	5.0
	100	35

TABLE K-4. PERCENT TRENCHING SAVED BY EACH MODEL PLANT

Cost Savings Scenario[a]	Trenching Saved										
	MP1[b]		MP2		MP3		MP4		MP5		Weighted[c,d] Average Trenching Saved
	ft	%	ft	%	ft	%	ft	%	ft	%	%
Scenario 1	85	100	105	100	165	100	205	100	265	100	100
Scenario 2	19	22.4	26	24.8	26	15.8	26	12.7	26	9.8	20.6
Scenario 3	29	34.1	42	40.0	75	45.5	104	50.7	106	40.0	37.8
Scenario 4	19	22.4	20	19.0	20	12.1	20	9.8	20	7.6	18.9

[a] Cost savings scenarios described in Table K-3.

[b] MP = Model Plant as described in Chapter 2, Section 2.3.1.

[c] Weighted averaged trenching saved based on distribution of facilities presented in Chapter 2, Table 2-3.

[d] Assumed 2 tanks for Model Plant 1, 3 tanks each for Model Plants 2 through 5.

length the savings represents. The weighted average savings for each scenario shown in Table K-4 was based upon the model plant diagrams found in Appendix B and the facility distribution shown in Chapter 2, Table 2-3. Because there is no information to the contrary, the frequency of occurrence for each underground piping system leak was assumed equal across all plant sizes. Therefore, the revised trenching cost for each model plant was calculated using the following equation:

$$C_T\ (1 - L_P) + \quad C_T\ (L_{pi} \times (1 - P_{tsi}))$$

where: C_T = Trenching cost for each model plant found in Tables B-9 through B-13.

L_P = Percentage of piping systems that leak (35%)

L_{pi} = Percentage of piping systems that leak under scenario i

P_{tsi} = Percent trenching cost saved under scenario i

For example, for a Model Plant 3 with an individual balance system, the above equation would look as follows:

$$\$4{,}950\ (1 - 35\%) + [\$4{,}950\ (16.9\%\ (1 - 100\%) + 11.8\%\ (1 - 15.8\%) + 1.3\%\ (1 - 45.5\%) + 5.0\%\ (1 - 12.1\%))] = \$3{,}963.$$

where: $4,950 = Trenching costs from Table B-11, Appendix B (165 ft x $30/ft).

After adding pipe assembly cost ($6/foot of trench) and the piping purchase cost ($1,779), the total underground piping installation cost would be $6,732 ($3,963 + $6/ft x 165 ft + $1,779). This represents a potential average cost savings of $987 dollars for Model Plant 3 underground costs (savings of 13 percent of underground costs and 8 percent of total capital costs). The maximum savings potential for a Model Plant 3 would include all the underground trenching costs ($4,950). This maximum savings represents 64 percent of the underground costs and 39 percent of total capital costs.

A similar calculation was made for each model plant. Table K-5 and K-6 summarize the impacts of a simultaneous Stage II/UST program on the Stage II per-facility capital and annual costs. These tables are presented in a format identical to Tables B-16 and B-17 of Appendix B

Table K-5. Generic Stage II Capital Costs Including UST Impacts: No Discounts

COMPONENT	COST OF COMPONENT		
	BALANCE	HYBRID	ASSIST
MODEL PLANT 1			
DISPENSER DIRECT COST	1,568	1,880	1,211
AUXILIARY DIRECT COST	0	0	5,238
PIPING DIRECT COST	3,380	3,160	3,500
TOTAL DIRECT COST	4,950	5,040	9,950
TOTAL INDIRECT COST	0	0	0
TOTAL CAPITAL COST	4,950	5,040	9,950
MODEL PLANT 2			
DISPENSER DIRECT COST	2,040	2,440	1,570
AUXILIARY DIRECT COST	0	0	5,238
PIPING DIRECT COST	4,280	4,140	3,930
TOTAL DIRECT COST	6,320	6,580	10,740
TOTAL INDIRECT COST	0	0	0
TOTAL CAPITAL COST	6,320	6,580	10,740
MODEL PLANT 3			
DISPENSER DIRECT COST	4,080	4,880	3,150
AUXILIARY DIRECT COST	0	0	5,238
PIPING DIRECT COST	6,870	6,730	6,030
TOTAL DIRECT COST	10,950	11,610	14,420
TOTAL INDIRECT COST	0	0	0
TOTAL CAPITAL COST	10,950	11,610	14,420
MODEL PLANT 4			
DISPENSER DIRECT COST	6,110	7,310	4,720
AUXILIARY DIRECT COST	0	0	5,238
PIPING DIRECT COST	8,490	8,450	7,920
TOTAL DIRECT COST	14,600	15,760	17,880
TOTAL INDIRECT COST	0	0	0
TOTAL CAPITAL COST	14,600	15,760	17,880
MODEL PLANT 5			
DISPENSER DIRECT COST	10,190	12,190	7,870
AUXILIARY DIRECT COST	0	0	5,238
PIPING DIRECT COST	11,150	11,220	10,090
TOTAL DIRECT COST	21,340	23,410	23,200
TOTAL INDIRECT COST	0	0	0
TOTAL CAPITAL COST	21,340	23,410	23,200

Table K-6. Generic Stage II Annual Costs Including UST Impacts: No Discounts

COMPONENT	ANNUAL COST OF COMPONENT		
	BALANCE	HYBRID	ASSIST
MODEL PLANT 1			
CAPITAL RECOVERY COST	644	679	1,570
MAINTENANCE COST	475	497	436
INSPECTION COST	0	0	0
OTHER INDIRECT COSTS	198	201	398
RECOVERY CREDIT	129	129	65
ADDITIONAL CREDITS	0	0	0
TOTAL ANNUALIZED COST	1,190	1,250	2,340
MODEL PLANT 2			
CAPITAL RECOVERY COST	826	890	1,690
MAINTENANCE COST	617	646	537
INSPECTION COST	0	0	0
OTHER INDIRECT COSTS	253	263	430
RECOVERY CREDIT	518	518	259
ADDITIONAL CREDITS	0	0	0
TOTAL ANNUALIZED COST	1,180	1,280	2,400
MODEL PLANT 3			
CAPITAL RECOVERY COST	1,480	1,610	2,200
MAINTENANCE COST	1,230	1,292	970
INSPECTION COST	0	0	0
OTHER INDIRECT COSTS	438	464	577
RECOVERY CREDIT	906	906	453
ADDITIONAL CREDITS	0	0	0
TOTAL ANNUALIZED COST	2,240	2,460	3,290
MODEL PLANT 4			
CAPITAL RECOVERY COST	2,030	2,250	2,690
MAINTENANCE COST	1,852	1,938	1,410
INSPECTION COST	0	0	0
OTHER INDIRECT COSTS	585	631	715
RECOVERY CREDIT	1,683	1,683	841
ADDITIONAL CREDITS	0	0	0
TOTAL ANNUALIZED COST	2,780	3,140	3,970
MODEL PLANT 5			
CAPITAL RECOVERY COST	3,070	3,450	3,500
MAINTENANCE COST	3,090	3,230	2,280
INSPECTION COST	0	0	0
OTHER INDIRECT COSTS	854	936	928
RECOVERY CREDIT	4,790	4,790	2,400
ADDITIONAL CREDITS	0	0	0
TOTAL ANNUALIZED COST	2,220	2,830	4,310

to enable a direct comparison. Table K-7 presents a comparison of weighted average capital and annual costs by model plant for a Stage II system with and without coordination with an UST program.

K.3 ESTIMATE OF IMPACTS IN NONATTAINMENT AREAS

The purpose of this section is to estimate the impacts of a simultaneous Stage II/UST program in nonattainment areas (27 areas and 61 areas). To allow for a true comparison, the estimates for costs, emissions, and cost effectiveness for a Stage II program with and without UST will be made using the same phase-in and cost assumptions.

First, an evaluation of the implementation schedule had to be performed. The current estimate by members of EPA's UST program predicts the UST standard to be final by mid-1988. The existing UST proposal package requires all existing bare tanks (70% of the population) to be monitored for leaks by mid-1991 and corrosion-resistant tanks monitored by mid-1993. Once leaks are found by monitoring, repairs to the tanks or piping must begin. For purposes of this analysis it was assumed that the Stage II piping would be installed at the time of the UST repairs. Therefore, it was assumed that 70% of the Stage II facilities would be installed in 3 years with the remainder installed by the end of 5 years.

This revised phase-in schedule was used in the same cost and emissions prediction models discussed in Chapters 2 and 3 of this document. Table K-8 summarizes the results of the comparison for cost, emissions, and cost effectiveness. This analysis indicates that, by combining the Stage II program with the UST program, and assuming a conservative 35 percent leakage rate and a linear phase-in of both programs, a savings in Stage II costs of about 6 percent would occur. If you use the more recent estimate of leakage (10 percent), a savings of about 2 percent would occur.

TABLE K-7. COMPARISON OF WEIGHTED[a] STAGE II CAPITAL AND ANNUAL COSTS WITH AND WITHOUT A SIMULTANEOUS UNDERGROUND STORAGE TANK (UST) PROGRAM

Model	Total Capital Costs, $			Total Annual Costs, $		
Plant	W/O UST	W/UST	% Diff	W/O UST	W/UST	% Diff
1	5,750	5,210	9.4	1,340	1,260	6.0
2	7,250	6,580	9.2	1,360	1,260	7.4
3	12,210	11,220	8.1	2,470	2,330	5.7
4	16,140	14,940	7.4	3,070	2,890	5.9
5	23,240	21,740	6.5	2,630	2,420	8.0

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[a] Weighted Stage II costs were estimated based on 80 percent balance systems, 15 percent hybrid systems, and 5 percent vacuum-assist systems, as in the remainder of the document.

TABLE K-8. IMPACTS OF THE UNDERGROUND STORAGE TANK (UST) PROGRAM ON STAGE II INSTALLATION COSTS IN NONATTAINMENT AREAS[a,b,c]

	Emission[d] Reduction, Mg/yr		Annualized Costs, $ Million		Cost Effectiveness, $/Mg		
NA Areas	Avg. Ann.	Annualized	W/UST	W/O UST	W/UST	W/O UST	% Diff
27 Areas	46-64	43-60	43-47	45-49	990-780	1,050-820	5.7%
61 Areas	71-98	66-92	66-72	70-76	990-780	1,050-820	5.7%

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a. With (w/) and without (w/o) UST projections for costs and emissions use the same phase-in rates (start mid-1988, 70% complete mid-1991, remainder complete mid-1993).

b. Range of values is from minimal enforcement to annual enforcement.

c. Values reflect the <10, <50 size exemption, percentage change for other exemption levels is about the same.

d. Emission reductions are the same for both the w/ and w/o UST scenarios.